~~RESTRICTED~~
~~Security Information~~

UNITED STATES NAVY

BIOLOGICAL WARFARE DEFENSE

TECHNICAL PUBLICATION

NAVDOCKS TP-PL-4

REV. 15 APRIL 1953

(REPRINTED 1 SEPT 1953,
INCORPORATING PRIOR CHANGES)

DEPARTMENT OF THE NAVY
BUREAU OF YARDS AND DOCKS
WASHINGTON 25, D.C.

~~RESTRICTED~~

Department of the Navy
Bureau of Yards and Docks
Washington, D. C.

This is the first revision of Biological Warfare Defense, which is the third in a series of publications being written by this Bureau on Passive Defense and Damage Control. It is intended to serve as a guide to naval shore activities in developing adequate protective and decontamination measures against biological warfare, and to assist the Civil Engineer Corps Officer in carrying out his assigned mission in biological warfare defense.

In developing defenses for naval stations, biological warfare has not been considered as an absolute weapon capable of disabling or destroying large portions of a community. On the other hand, it would be dangerous to consider it as an impractical weapon that presents no danger.

Although biological warfare has never been used on a large scale, its employment by an enemy is possible. Therefore, adequate preparation should be made to minimize the effects in case an attack is made. In the event of biological warfare, the Civil Engineer Corps Officer may be required to assume an important role in the defense plan of his station.

J. F. Jelley

J. F. JELLEY
RADM (CEC) USN
Chief, Bureau of Yards and Docks

FOREWORD

For years nature has directed forms of biological warfare against man, but the medical profession is constantly devising and applying improved preventive and remedial measures to combat such dangers to health. Today, with few exceptions, infectious diseases are well controlled in this country. The knowledge, experience, and technological improvements employed in the control of disease occasioned by natural causes are available from medical authorities to cope efficiently with biological weapons that might be employed by an enemy.

This publication is based on the assumption that an enemy with reasonably modern scientific facilities could produce effective biological warfare agents in sufficiently large quantities to be used as a weapon. Any agent that could effect high fatality or morbidity rates could be adapted for use in biological warfare. This publication, therefore, presents general principles that apply to all agents rather than detailed information regarding a few specific agents.

Part A covers briefly the classification and characteristics of biological warfare agents, methods of infection, possible means of attack, and defensive measures. Part B presents procedures for detecting biological agents and for locating and marking contaminated areas. Part C pertains to the protective measures to be taken, such as providing individual protective equipment and shelters and safeguarding food and water supplies.

Part D contains detailed information on standard chemicals and compounds suitable for biological decontamination and also methods for decontaminating interior and exterior surfaces, personnel, equipment, water, and food. Part E gives a basis for estimating material and equipment requirements and a proposed method for making estimates. It also suggests a defense bill and program of training.

BIOLOGICAL WARFARE DEFENSE

CONTENTS

PART A. BIOLOGICAL WARFARE AGENTS

PART B. DETECTION OF BIOLOGICAL AGENTS

PART C. PROTECTION

Section 1. GENERAL

Section 2. INDIVIDUAL PROTECTIVE EQUIPMENT

Section 3. PROTECTIVE SHELTERS

Section 4. PROTECTION OF WATER AND FOOD

PART D. DECONTAMINATION

Section 1. INTRODUCTION

Change 1
14 July 1953

ILLUSTRATIONS

TABLES

BIOLOGICAL WARFARE DEFENSE

PART A. BIOLOGICAL WARFARE AGENTS

Section 1. GENERAL

A1.01 Purpose and Scope

1. Purpose. This publication contains technical information for the use of shore activities, and particularly for Public Works Officers, in planning defensive measures against possible biological warfare attacks and in developing effective measures to minimize the resulting confusion and casualties.

2. Scope. Various general aspects of biological warfare are discussed here, such as the possibility of attack, methods of offense and defense, characteristics of biological warfare agents, and preventive measures to be taken. Other specific phases covered are:

(1) The detection of biological agents
(2) Individual and group protective measures
(3) Decontamination procedures
(4) Materials and equipment recommended, and the training necessary to carry on an effective defense program

Medical aspects of biological warfare are not treated in this publication except as they pertain to the defense program in general, and offensive strategy and tactics are mentioned only in connection with defensive countermeasures.

A1.02 Responsibility for Biological Warfare Defense

In accordance with Navy Regulations, Article 0455, paragraph 9, the Bureau of Yards and Docks is responsible for the development, procurement, and distribution of materials and appliances for defense ashore against chemical, biological, and radiological warfare, except instruments for detection and measurement of radioactivity. This responsibility covers all shore establishments under cognizance of the Navy.

A1.03 Biological Warfare Defined

Biological warfare is the intentional use of living agents and toxins, such as bacteria, viruses, and other microorganisms or pathogens, to produce death or disability

in man and animals, or to injure or destroy plants and other vegetation. The term "biological" is used here rather than "bacteriological" because it includes not only the use of germs but insect pests as vectors, or carriers, and other destructive agents. Biological warfare is a weapon primarily directed against persons, but it may be used against animals and plants. It does no structural damage to buildings or other inanimate objects. An enemy would employ biological warfare against us to:

(1) Reduce the means of making war by incapacitating personnel
(2) Reduce the will to war by adversely affecting the morale of personnel
(3) Reduce the means of making war by attacking livestock and destroying crops and agricultural products

A1.04 Biological Warfare Agents

1. Classification. Biological warfare agents may be classified as persistent and nonpersistent. The persistent agents will remain effective for a long period and can be very much more resistant to the elements than even the most persistent chemical agents. This has obvious consequences both in attack and in defense. Biological agents may also be classified according to the degree of contagion engendered. The major groups, based on their effects, are as follows:

(1) Those that produce temporary incapacity only, although it may be of several weeks' duration
(2) Those that result in a high percentage of deaths or permanent disability

2. Characteristics. The most important property of these living agents is their ability to multiply in the body of the person infected. This means that exceedingly small doses can produce disease, but sometimes the effects are delayed for days or even weeks while the organisms multiply. However, some germs are very sensitive to destructive influences, and this is a governing factor in determining their suitability for employment as biological warfare agents. In general, they are more susceptible than are chemical agents to the effects of heat, light, storage, and explosive forces. They present problems, therefore, both in storage and in dissemination as a weapon.

A1.05 Simulant Agents

Simulant BW agents are microorganisms or compounds having little or no pathogenicity or toxicity, but otherwise

resembling true BW agents in certain characteristics or properties, such as viability, size, food or cultural requirements, growth characteristics, persistency, and routes of invasion. They are particularly useful in field testing the behavior of munitions, determination of effect of particle size on penetration of the air passages of animals, survival of vegetable and spore-bearing organisms under experimental and environmental conditions, testing of protective devices and procedures, and for training purposes. Examples of microbial simulants are serratia marcescens or Bacillus prodigiosus, a vegetable nonsporulating organism, and Bacillus globigii, a spore-forming rod-shaped bacterium.

A1.06 Methods of Infection

Biological warfare agents must, of course, gain entrance into the body before they can cause any ill effects. The body may be infected by inhalation, by swallowing, or by agents entering the body through the skin. Generally the skin must be damaged before agents may enter; in rare instances, however, agents may infect through undamaged skin.

From the standpoint of the weapon designer, the most practical method of initiating infection is to disperse the agents as clouds of minute airborne particles (aerosols) in areas where they may be inhaled. From the defensive aspect, such an aerosol would subject exposed personnel to the following hazards:

(1.) Danger of inhalation of the biological warfare agent as an aerosol resulting from the explosion of a bomb, as the agent remains suspended in the air. (Primary cloud.)

(2.) Danger of inhalation of the biological warfare agent deposited initially on clothing, equipment, and ground, but later raised into the air as a "shake-off" from clothing or as a "dust" from the ground after being disturbed by the passage of men or vehicles. (Secondary Cloud.)

(3.) Danger of infection through the skin, facilitated by cuts and abrasions. This may result from contact with either a primary or secondary aerosol of the agent, or with contaminated surfaces.

(4.) Danger of swallowing contaminated foods or liquids.

A1.07 Comparison of Biological and Chemical Warfare Agents

In general, biological and chemical warfare agents can be compared or contrasted as follows:

(1.) Both biological and chemical warfare agents may be either persistent or nonpersistent. Their persistency may vary from a few hours to many years.

(2.) A given weight of a biological warfare agent is potentially much more dangerous (that is, may result in many more casualties) than an equal weight of the most effective poison gas known.

(3.) In spite of technical difficulties connected with the dispersion of biological agents, it is believed that they could be a hundred or more times as effective as the well-known chemical agents.

(4.) Some of the biological warfare agents may cause death; others result in long and incapacitating illness. In all cases, with the exception of toxins, the onset of the symptoms will be delayed for a minimum of a few days and frequently a few weeks, whereas chemical agents and toxins become effective almost immediately.

(5.) Biological agents in dangerous concentrations can not be detected by the human senses, and no practicable means are now foreseen by which it will be possible to detect an aerosol quickly enough to allow masks to be applied. On the other hand, chemical agents may be generally detected by means of various chemical-detection devices.

A1.08 Possible Means of Attack

Although man, animals, and plants are subject to many diseases, careful study shows that, for one or more reasons, remarkably few pathogens are likely to be selected for use in war. Most agents are unsuitable because of (a) low, irregular, or undependable infecting power when exposed to air, (b) the natural or artificial resistance, or immunity, of the population, or (c) undue persistence of the agent for so long a period as to make occupation of the area impossible even for the using force. Probably not more than twenty species of disease-producing agents need be given close attention.

Various methods could be used for maximum effectiveness in the intentional dissemination of pathogenic agents against shore activities. The most efficient means appears to be through the air, by liberating fine airborne particles that would travel over the target. Under these conditions, contamination might be widespread, but it would have only a limited degree of persistence.

The airborne form of biological warfare attack may be conducted in a way to circumvent control procedures utilized in preventive medicine during natural disease outbreaks. In airborne biological warfare, the infective agent can be applied in much higher concentrations than occur in nature. Also, the infective-agent particle size may be small enough to reach the air cells of the lungs, whereas pathogenic organisms in nature are usually in clumps, pus, and saliva, and they are seldom small enough to reach the air cells. These natural pathogens are generally filtered out in the upper respiratory tract.

In nature, most pathogens usually die off very rapidly in the air, whereas in biological warfare, they might be disseminated in a form resistant to the deleterious effects of the atmosphere.

It is possible that storage reservoirs and foodstuffs might be infected in a number of ways and that livestock might be attacked through the contamination of their feed. For general military purposes, however, the most promising target would be civilian or military personnel when attacked by large clouds of one or more agents released from aircraft or submarines.

A1.09 Possibility of Effective Attack

History has taught us that an enemy will employ any novel weapon that he believes his intended victim is unprepared to meet. This was proved when chemical warfare was first used in 1915. Conversely, an enemy may hesitate to use such a weapon, however effective, if he suspects that his adversary is in a position to protect himself adequately against it or to retaliate with it.

Biological warfare on a large scale is as yet an untried weapon, and statements and conclusions are made solely on the assumption that it can be made effective. Because biological warfare agents have not been used under war conditions, a reliable estimate of their effectiveness against man can not now be made: the results of animal experiments form the only basis for drawing any conclusions in this regard. The possibilities of biological warfare, however, are great enough to demand a close study of the subject and the organization of a program to deal with the technical and organizational problems of defense.

A1.10 Means of Defense

1. General. Defensive measures have not been put to the test of war, and practical experiments on man can not be

made readily for the purpose of developing protective or preventive measures. It is not possible, therefore, to make precise statements based on actual war experience. However, it is reasonable to make plans for defense based upon the procedures that are known to be effective against infectious diseases of natural origin.

As previously stated, the most likely method of attack would be by aircraft equipped to release an aerosol. Although climatic and meteorological factors would make it difficult in many cases for an enemy to deliver an infective dose, certain weather conditions might facilitate the production of a dose capable of infecting large numbers of personnel. The same meteorological conditions that made smog a serious problem can also increase the risks from a biological warfare airborne attack.

The hazard from such an attack is twofold: direct inhalation of particles from the aerosol, and infection from the organisms that settle on the ground, clothing, and skin. When these organisms are shaken off the clothing or are disturbed by movement, they may be inhaled, swallowed, or taken into the body through the skin, particularly when the skin is injured. It is obvious, therefore, that the main defense against biological warfare agents lies in preventing access of the organisms to the body, insofar as possible, by means of masks, protective clothing, and suppressants, and by building up the body's resistance against such organisms, as by preventive inoculation.

2. Preventive Inoculation. Preventive inoculation is strictly in the medical field and will be discussed only briefly here. Where a suitable vaccine is available, preventive inoculation will give a good measure of protection against infection by a biological agent. However, there are effective vaccines for only a few of the biological warfare agents that might be used; and even when a vaccine is available, it takes time to develop resistance to the agent. Most available vaccines, although effective against ordinary exposure, may be relatively ineffective against extraordinarily high concentrations, such as might be experienced in biological warfare attacks.

Although mass inoculation of the civil population would be a gigantic task, even if limited to special areas of the country, it should prove very useful in preventing or reducing casualties. Mass immunization of the services, on the other hand, presents no great administrative difficulties. The technical and administrative problems in connection with inoculation are being studied.

3. Other Defensive Measures. Detailed defense measures are covered in this publication as follows:

(1) Detection and identification of the agents used by the enemy, Part B
(2) Physical protection, Part C
(3) Decontamination, Part D
(4) Recommended materials and equipment for biological warfare defense, Part E

PART B. DETECTION OF BIOLOGICAL AGENTS

Section 1. GENERAL

B1.01 Importance of Early Detection

1. Rapid Warning. Rapid warning of a BW attack--within one or two minutes at the most--is essential for effective counteraction. Obviously, personnel can not be constantly on the alert and fully protected because it is both impracticable and economically impossible for them to perform their required duties while masked or confined to protective shelters. At the time of the attack, the important factor is that a warning be sounded in time for personnel to seek protection. It is not necessary for them to know the kind of agent being used, because approved protective measures are effective against all BW and CW agents. BW aerosols are invisible and have no warning odor; it being impossible for individuals to detect their presence through the senses, physical detection devices are necessary.

2. Early Identification. When the presence of an attack has been established and protective measures taken, samples should be obtained immediately so that the biological agent can be identified. Early identification of the agent will enable medical authorities to make preparations for treatment of casualties that may arise among exposed persons. The incubation period (time between exposure and the onset of illness) is several days for most agents, hence there is considerably more time available for identification than there is for warning.

3. Problem of Detection. It is very desirable that information concerning the attack reach medical personnel in time to make advance preparation before casualties appear. Thus, the problem of detection breaks down into three phases: rapid warning, sampling, and early identification, each of which will be discussed below.

B1.02 Warning

The warning phase calls for the use of physical devices, or special intelligence may be received that a BW attack has taken place.

1. Devices. It is possible that some instrument or mechanism could be devised that would continuously sample any one medium, such as air, and sound an alarm in the event of an abnormal increase of organisms in that medium. Such an instrument is not now available for field issue.

2. Pattern of Established Warfare. After it has been definitely established that biological warfare has been initiated by the enemy, it may be assumed that attacks will recur. In many cases, the method of delivery will follow a pattern that will serve as an automatic alert that can be recognized. This pattern may comprise the presence of enemy aircraft and characteristic bomb detonations. Even if a specific warning device were available, as outlined above, this pattern would often serve as the first indication that an attack has occurred.

3. Intelligence.

a. Wartime. Even though detection devices may be operating, the initial warning may be given by sources of intelligence. In time of war, intelligence is obtained from special organizations such as the Naval Intelligence Service, the Central Intelligence Agency, the State Department, and the Federal Bureau of Investigation. In the field, information may be acquired from underground organizations, refugees, and the local population. Information may also be gleaned from captured enemy documents such as orders, health records, memoranda, correspondence, and manuals; as well as captured munitions, biological materials, defensive and offensive equipment, blood tests of prisoners of war, and aerial reconnaissance. These are but a few of the possible sources of information that may be used to determine the actual or contemplated enemy use of biological agents in time of war.

b. Peacetime. In peacetime, sources of information are much more limited; all available intelligence reports must, therefore, be scrutinized for any indication of preparations for a sneak attack. Peacetime sources of information include diplomatic channels, travelers and friends in foreign countries, displaced persons, refugees, foreign papers, periodicals, and miscellaneous reports. Underground agencies that exist within a hostile nation also serve as an excellent source of information.

4. Epidemiology. In the early stages of biological warfare, it may be necessary to rely on epidemiology, the study of disease outbreaks, to sound the warning that a station has been attacked. However, reliance on epidemiological warning is undesirable because the attack can not be verified until the biological warfare agent has caused casualties. Furthermore, it may be extremely difficult to determine whether the source of infection was natural or resulted from a covert attack by an enemy.

B1.03 Sampling

Field sampling is the actual collection of organisms from air, water, surfaces, or other suspected media. Processing samples for identification is a long procedure. Sampling generally can not be undertaken as a matter of routine. Therefore, to be practicable, sampling must depend on some means of warning to indicate when and where sampling is warranted.

B1.04 Identification

Identification of biological agents is primarily the concern of the medical profession. For that reason, the technical details are not discussed in this publication. In general, it will be necessary to rely on the standard biological laboratory methods and techniques developed over the years. New developments utilizing physical techniques may also aid the rapid identification of suspected organisms.

In the initial phases of biological warfare, epidemiology may possibly give the first warning of an attack. By the same token, the clinical diagnosis of casualties may serve as the means of identification.

Section 2. FIELD SAMPLING PROCEDURES

B2.01 General

Of the possible methods of detection outlined in Section 1, field sampling is the one the reader will generally be most concerned with. As noted, this does not mean that sampling will necessarily be the primary method of detection and at best is only one step in detection, but it is the method requiring the use of locally trained personnel. For these reasons field sampling techniques and equipment are discussed in some detail.

B2.02 Purpose of Samples

The purpose of collecting samples is twofold. The first

and probably the most important is to furnish the identification laboratories (details of operation are not considered in this publication) with the material on which to base an identification. The second is to facilitate the location and marking of contaminated areas, buildings, water and food stores, and an indication of treatment of personnel.

B2.03 Field Sampling Kit

1. Make-up of Kit. A BW field sampling kit containing the necessary materials and equipment for the collection of field samples is currently undergoing field test, and will be made available for distribution as soon as possible. The materials, equipment, and supplies are fitted into a suitable carrying case that provides a field "work bench" when opened. The assembled kit, ready for use, is approximately 8" x 10" x 16" and weighs 22 pounds. A kit and its contents is shown in Figure 1. The design of the items is tentative; however, future items will accomplish the same purpose and in the same general manner. The principal items are:

(1) Vacuum Pump. The vacuum pump is to be used in conjunction with the impinger (3) for the collection of air samples and filtration of fluid through membrane filters.

(2) Membrane Filters. Membrane filters are designed to separate organisms from water and impinger fluid. When placed in the plastic dish (4) with nutrient (5),they also serve as a base for growing and shipping the sample organisms.

(3) Impinger. The impinger is used for collection of air samples. This device holds the impinger fluid (6) through which contaminated air is pumped (see paragraph 1 of B2.06). This item with the sump tank (7) is also used for filtering exposed impinger fluid through the membrane filter.

(4) Plastic Dish and Blotter. A plastic dish and blotter are furnished in the kit to hold exposed membrane filters and nutrient (5) during transportation to the laboratory.

(5) Nutrient Syrettes. Nutrient syrettes contain a sterile nutrient to be added to the plastic dish for promoting growth of organisms on exposed membrane filters.

(6) Impinger Fluid and Antifoam Solution. Impinger fluid and antifoam solution are used in the impinger to entrap organisms from air pumped through the liquid.

(7) Sump Tank. Sump tanks are used in conjunction with impinger (3) and the hydrosol filtration unit (HFU) during filtration of liquids.

(8) Cotton Swabs. Cotton swabs are dampened and rubbed over the suspected surface (see B2.08).

(9) Gelatin Diluent. Gelatin diluent is used to dampen cotton swabs (8) when samples are taken from a suspected surface.

(10) MFI Holders. MFI holders are used to hold assembled impinger and filtration units during operation. This device is attached to the carrying case.

(11) Incubation Vest. The incubation vest, containing pockets to hold plastic dishes (4), is worn next to the body so that the body heat will promote growth of the sample before the sample is sent to the laboratory.

(12) Plastic Bags. Plastic bags are provided to convey solid samples to the laboratory.

(13) Hydrosol Filtration Units. Hydrosol filtration units are used for filtration of water samples and the wash from exposed cotton swabs.

(14) Decontamination Equipment. A hypochlorite solution is included in the kit for decontamination of equipment that may be washed or soaked (see D6.03).

(15) Rubber Gloves. Rubber gloves are provided to wear beneath the impregnated gloves (see B2.10). During actual operation of the sampling equipment, it will be necessary to remove the outer gloves.

(16) Miscellaneous Equipment. In addition to the foregoing items, there are also included: tape for binding bags or similar items together; notebook for keeping pertinent data regarding samples, and wax pencils to mark sample containers.

(17) Instructions. Detailed instructions are provided for the use of the materials and equipment.

2. General Operation of BW Field Sampling Kit. The operation of the kit described above is designed principally around the membrane filter. The organisms are collected in liquid and transferred to the filter by simple filtration.

Figure 1
BW Field Sampling Kit

Growth is started when the exposed filters are placed in the plastic dishes with a suitable nutrient (see Figure 1a). The rate of growth is increased by carrying the samples in the incubation vest, where the body temperature of the wearer keeps the sample near the optimum growth temperature for most bacteria. Promoting growth before arrival at the laboratory will considerably reduce the time required for identification.

3. Resupply. Each of these kits contains only a limited amount of expendable items; it will be necessary, therefore, to maintain a stock to resupply these kits during any sampling operation as outlined in this publication. Such items include plastic dishes, membrane filters, nutrient syrettes, impinger fluid, cotton swabs, gelatin diluent, and plastic bags.

B2.04 Selection of Samples

1. Primary BW Cloud. If no outside clues are available so that some possibilities may be eliminated, the actual identification of an agent may require many man-hours of effort. Therefore, the submission of samples that do not represent the condition in the field must be avoided. As an example, it is desirable that samples to be used for the purpose of identification be collected directly from the primary BW cloud instead of from surfaces in the area of attack, principally because there are fewer naturally occurring organisms in the air than on surfaces. To identify an agent positively, it is necessary for the laboratory to identify every colony in a sample. If a sample indicated the presence of 10 types of organisms, 5 times more laboratory work would be required than if only 2 types appeared. Thus the fewer naturally occurring and nonpathogenic organisms included in the sample, the more quickly the identification can be made.

2. Importance of Locations and Techniques. Once the identification of an agent has been established, surface sampling does not present as great a problem. Laboratory technicians will know what to look for and by simple examination will eliminate many of the possibilities appearing in a sample. This does not mean, however, that there will be laboratory capacity to process samples that have been chosen indiscriminately. The success of the sampling will largely depend on the skill with which sampling locations are chosen and techniques selected.

B2.05 Locating and Marking Contaminated Areas

As soon as biological contamination is located in an

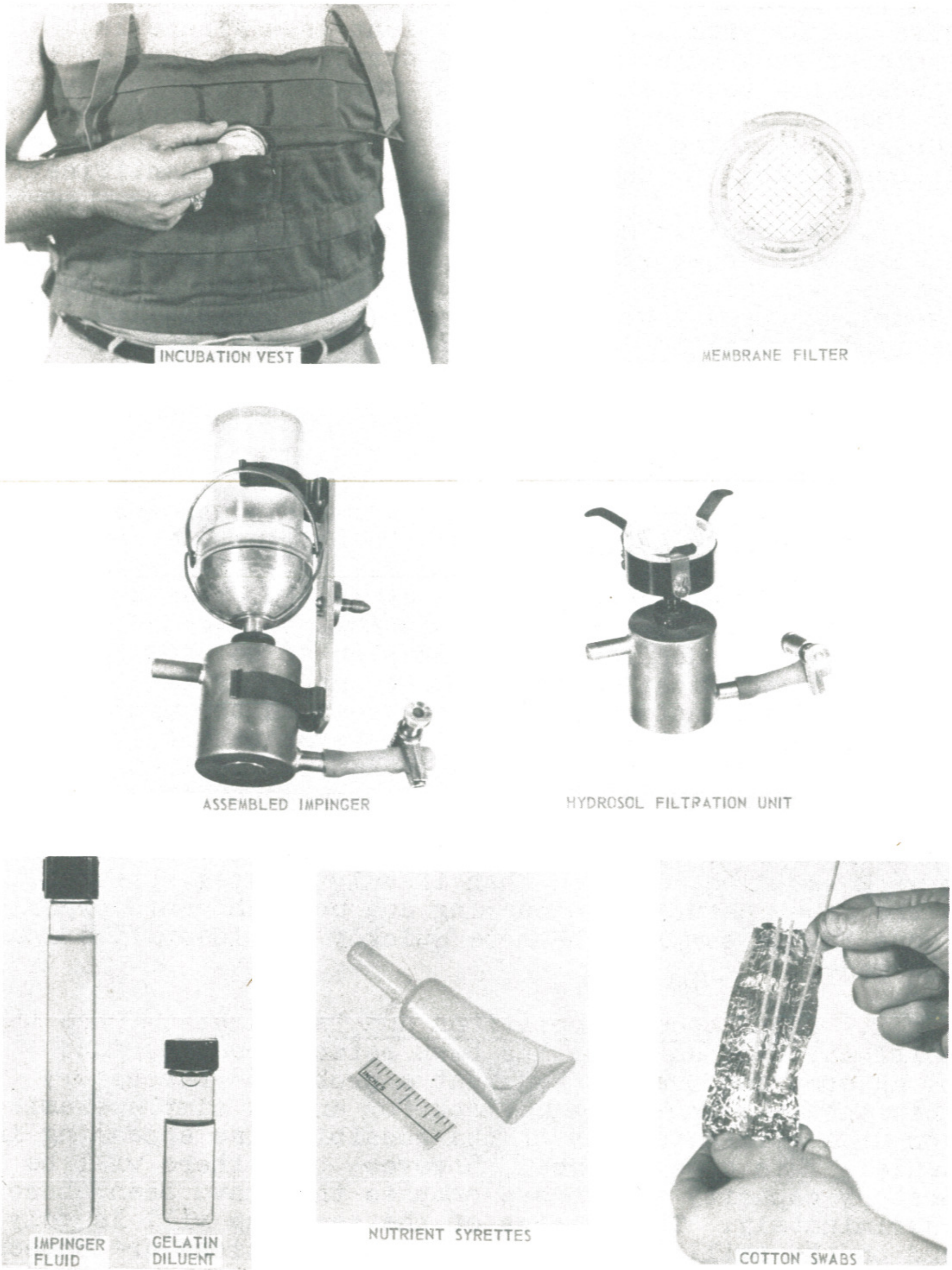


Figure 1a
Principal Components for BW Detection Kit

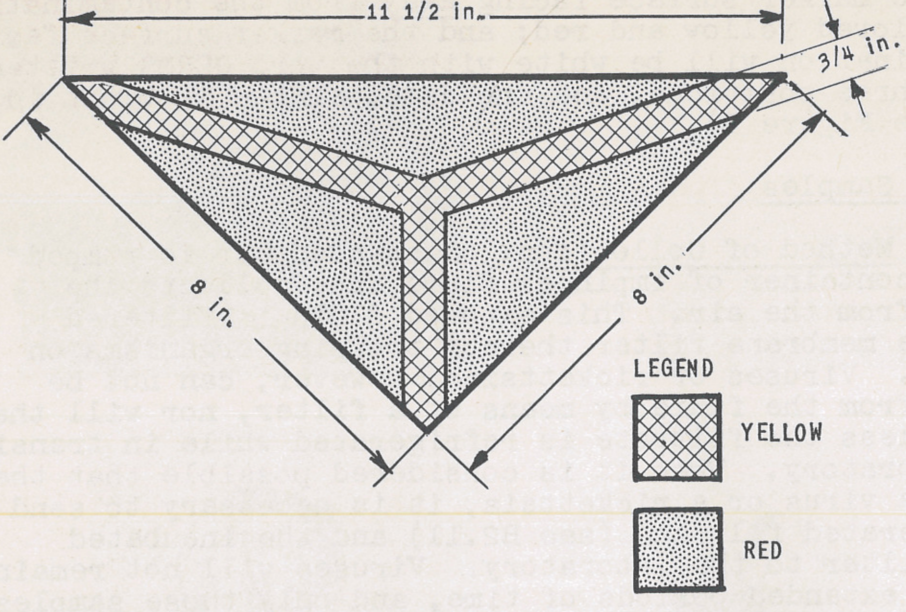
area, the boundaries should be marked with triangular warning signs. The marker surface facing away from the contamination will be colored yellow and red; and the marker surface facing the contamination will be white with the word GERMS written in black in three positions, and the date painted in black in the center (see Figure 2).

B2.06 Air Samples

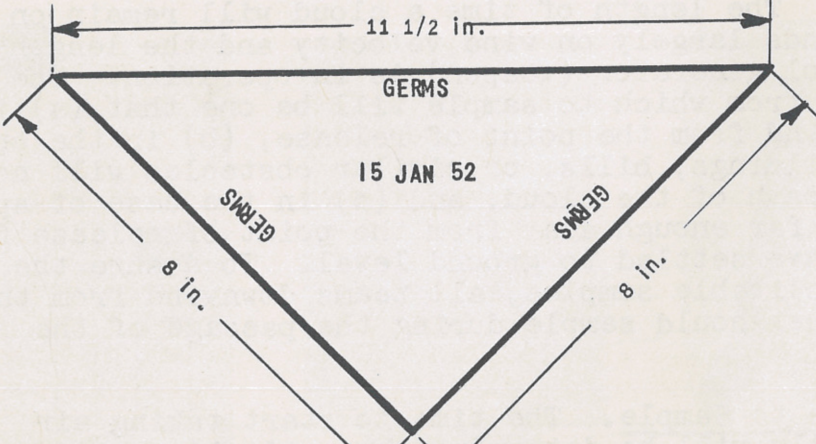
1. Method of Collection. Suspected air is pumped through a container of impinger fluid that collects the organisms from the air. This exposed fluid is filtered through the membrane filter thereby trapping organisms on the filter. Viruses or rickettsiae, however, can not be separated from the fluid by means of a filter, nor will they survive unless the filtrate is refrigerated while in transit to the laboratory. When it is considered possible that the agent was a virus or a rickettsia, it is necessary to send the refrigerated filtrate (see B2.11) and the incubated membrane filter to the laboratory. Viruses will not remain viable for extended periods of time, and only those samples submitted for the purpose of identification of the agent will be considered for the possibility of virus. If it is determined that the agent used was a virus, decontamination generally will not be required as they will die off naturally. Under these conditions, the necessity for determining extent of contamination is of minor importance.

2. Place to Sample. To establish the identity of a BW agent, it is desirable to collect the sample from the primary cloud. The length of time a cloud will remain on a station depends largely on wind velocity and the length of time the aerosol generator (weapon) is in operation. The ideal location from which to sample will be one that (a) is directly downwind from the point of release, (b) in the open so that trees, buildings, hills, or similar obstacles will not interrupt the path of the cloud, and (c) in the case of sprays from aircraft, far enough away from the point of release for the spray to have settled to ground level. To assure the collection of suitable samples, all teams downwind from the point of release should sample during the passage of the cloud.

3. Time to Sample. The time to start taking air samples generally will be determined by estimating wind velocity and distance to suspected point of release. With these data, the time required for the cloud to reach the sampling location may be estimated. If it can be determined positively when the cloud is over the sampling station, the sampling pump should be operated for five minutes. If the location of the cloud is not positively known, the sampling



Front view of biological-contamination marker



Rear view of biological-contamination marker

Figure 2

Biological-Contamination Marker

time should be extended to ten minutes. The increased sampling time allows for possible errors in estimating the time of arrival of the aerosol. When directed by appropriate authority, air samples should be taken as a matter of routine during all air alerts, or when suspicious clouds are released from enemy equipment or munitions.

4. For Other than Identification.

a. Purpose. In some cases air samples may be required for the purpose of detection of secondary aerosol from contaminated terrain or equipment. For example, samples may be required to determine the effectiveness of suppressants (see D3.12). The equipment and procedure for this purpose would be essentially the same as that outlined in paragraph 1 of B2.06.

b. Modifying Factors. The conditions under which the samples are taken and the purpose for which they are to be used must be carefully considered. If it is desired to determine the amount of secondary aerosol raised by traffic on a road, samples should be taken downwind during a peak traffic period. If the objective is to determine the amount of secondary aerosol from open terrain, samples should be taken during a period of minimum wind velocity when the surface is free from dew or other forms of moisture.

B2.07 Water Samples

1. Method. Water samples are taken directly from the suspected source and filtered through the membrane filters held in a hydrosol filtration unit. The organisms are trapped on the filter, which is then processed for incubation and shipment to the laboratory as outlined in the instructions with the field sampling kit. Sampling techniques vary with the type of water storage being sampled; these types may be broadly classified as raw water sources and treated water storage and distribution.

2. Raw Water Sources. Lakes and other large open bodies of water suspected of BW contamination should be sampled as close as possible to the intake. Three samples of approximately 1,000 cu cm should be taken from the surface level. Flowing streams should be sampled at the surface from two locations approximately 100 and 1,000 feet upstream from the intake. Each sample should be approximately 1,000 cu cm.

3. Treated Water Storage. Storage tanks and reservoirs for treated water should be sampled at the surface and from the discharge pipe. Unless the storage capacity is very large,

one set of samples will generally be sufficient. To indicate possible contamination in a distribution system, samples of approximately 1,000 cu cm each will be required. Unless there is some obvious reason for doing otherwise, samples should be taken from the mains instead of the laterals. Directly connected service connection or hydrants are suitable sampling points. A sample for each 1/2 mile of main or key locations will indicate any contamination in the system, and if all samples are taken simultaneously, they may serve as a guide to the location of the source of contamination.

B2.08 <u>Surface Samples</u>

1. <u>Method</u>. Surface samples are taken by rubbing a dampened cotton swab over a suspected surface. The contaminant is then "washed" from the swab by vigorous shaking in gelatin diluent. The organisms are filtered out of the diluent as described in paragraph 1 of B2.07. If virus is suspected, the filtrate with the incubated membrane filter will be forwarded to the laboratory (see B2.11).

2. <u>Kinds of Surfaces</u>. The surfaces selected should not have been protected by trees, buildings, hills, or similar obstructions, nor subjected to direct sunlight or temperatures appreciably different from that of the ambient temperature. Surfaces of window rail and muntins most nearly meet the foregoing requirements provided that they are the right height from the ground (4 to 6 feet), and are nearly perpendicular to the path of the cloud. Should surfaces other than window rails be selected, good choices would be smoothly painted wood or metal surfaces that meet the other general requirements. A minimum of 12 samples should be taken approximately 100 feet apart near the center of the area where the cloud passed.

3. <u>Sampling to Identify Agent</u>.

a. <u>Place to Sample</u>. In the case of munitions (bombs or other ground release), the best location for surface sampling would be at or near the point of release, the concentration of agents being highest at that point. Fragments from munitions, leaves of vegetation, stones, and other debris near the point of release provide excellent sources for samples. In addition to the surface sample, the material itself, if possible, should be forwarded to the laboratory. If the suspected agent was released as a spray from aircraft, surfaces known to be in the path of the cloud will provide the only source for samples. If the path of the cloud is known, samples should be taken from exterior smooth, clean surfaces that were normal to the direction of the cloud movement.

b. Area of Contamination Unknown. It is possible that the path of the cloud will not be known. Sampling in this situation may follow one of two possible patterns. The first would be to take four complete sets (12 samples per set) of samples, based on four possible wind directions. The second would be to sample horizontal surfaces where the direction of cloud path would have had little or no effect. The latter system is preferable, especially if considerable time has elapsed between suspected attack and time of sampling.

4. Sampling to Determine Extent of Contamination (Exterior). Surface sampling will generally be used to determine the extent of contamination resulting from a BW attack.

a. Sampling Pattern. A definite sampling pattern will be helpful to reduce to a minimum the laboratory work required in processing these samples (a large number of samples may be required for this purpose). One suitable pattern would consist of starting at or near the center of suspected area (if not known, center of area to be sampled), and sample around that point along the circumference of concentric circles or station blocks. (See Figure 2a). The diameter of each consecutive sampling ring should be approximately 800 feet larger than the preceding one. Samples should be taken every 400 feet (minimum) around the circumference.

b. Use of Map by Laboratory. By comparing the sample locations with a map of the area, it may be possible for the laboratory to omit certain samples if it becomes obvious that they were taken outside a contaminated area. The laboratory may also be able, by study of sampling locations, to determine the extent of contamination by "bracketing" the area. This system, while not reducing the field work, would tend to reduce the very complicated laboratory work. A map of the area should be submitted with samples to the laboratory showing location of each of the samples. Sample locations on the map should correspond with the symbols used in marking the samples.

c. Suitable Surfaces. In general, suitable surfaces for sampling for this purpose will be the same as those described in paragraph 2 of B2.08 except that most samples should be taken from horizontal surfaces as wind direction at each point where the cloud passed may not be determined. Possible surfaces for sampling of this type include wood (preferably painted), metal, smooth concrete or asphalt, vegetative leaves, and other similar types. A surface approximately 9 square inches in area should be wiped with a sterile

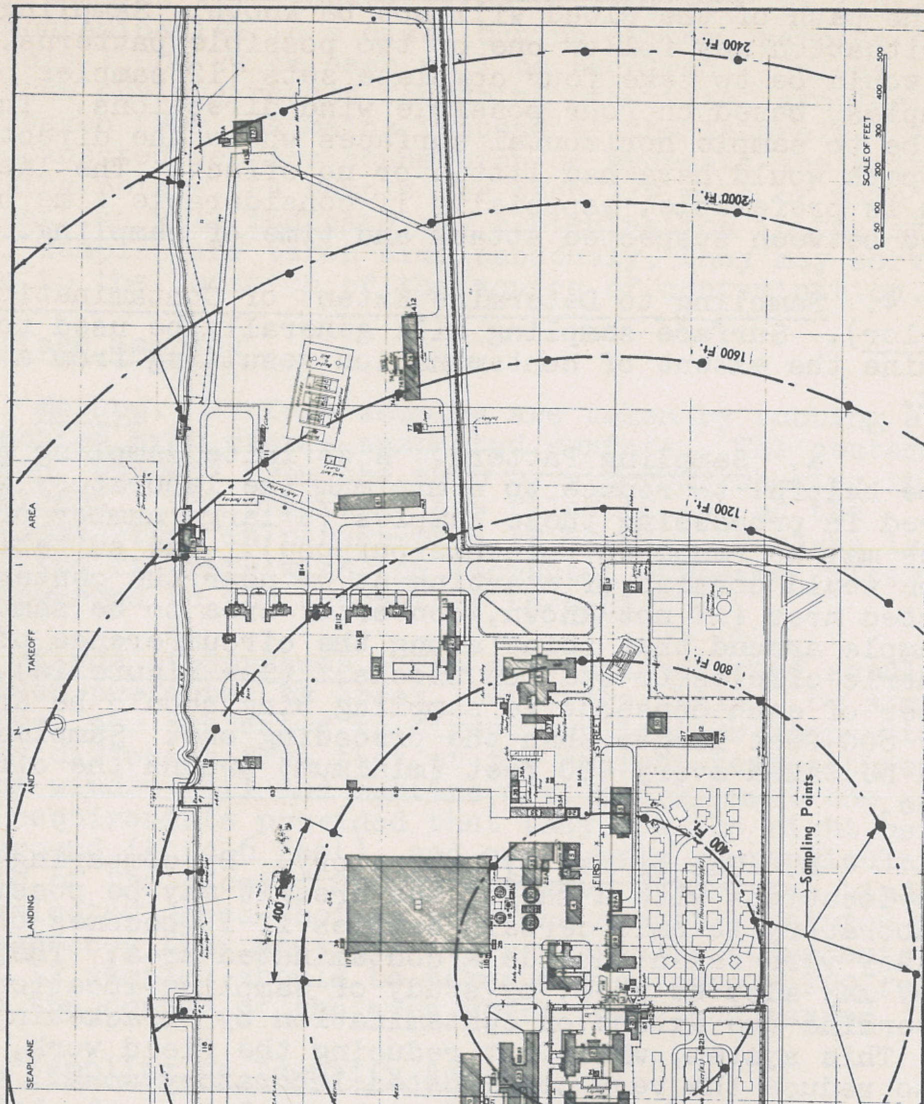


Figure 2a
Suggested Sampling Pattern

cotton swab, then processed as outlined in the instructions contained in the kit.

5. Sampling to Determine Extent of Contamination (Interior).

a. Place to Sample. To determine the extent of contamination inside buildings, it will generally be necessary to resort to samples from interior surfaces. If the suspected building contains mechanical ventilation that was in operation during the attack, one sample from the fan blade and two from the surface of the exhaust plenum will furnish an indication regarding the contamination within the building. If the suspected building does not contain mechanical ventilation, four surface samples should be taken for each 4,000 to 6,000 square feet of floor space. In multistory buildings without mechanical ventilation, sampling should be repeated on every other floor throughout the building. The sample should be equally divided between horizontal and vertical surfaces. The same type surface outlined in paragraph 2 of B2.08 should be selected. Care, however, should be exercised to select surfaces that have not been disturbed or cleaned after the suspected attack.

B2.09 Suspicious Objects

1. Purpose of Solid Samples. Generally, all solid samples will be collected for the purpose of identification of the agent rather than for the purpose of determining the extent of contamination.

2. Definition of Solid Sample. "Solid sample" as used in this publication means a piece of material, sample of soil, or an animal for shipment to the laboratory instead of actual collection of organisms discussed in the other forms of sampling. For example, a fragment from a suspected shell, a dead rat, or a mouse would be likely samples.

3. Pattern. After a swab sample has been taken from the surface of the solid object (if possible), the object should be placed in a container provided in the kit and forwarded to the laboratory. A guide to the selection of suitable samples of this type is difficult because of the many variations in field conditions. If the suspected attack is launched by bombs or other similar types of munitions, debris from the bomb crater may be highly contaminated and would, therefore, be desirable. If dead mice or other small animals are found in the area, they should be refrigerated and forwarded to the laboratory (see B2.11). If infected, they are ideal for the purpose of identification.

B2.10 Sampling Teams

1. Personnel of Teams. The personnel of decontamination squads (see D1.06) are especially trained in atomic, biological, and chemical warfare defense. For this reason, selected members of these squads are ideally suited for special training as sampling teams. Under most conditions two men should be assigned to each team, one for the manipulation of the equipment and the second to act as an assistant and a notekeeper, marking the samples for later identification and maintaining the field records. The notekeeper may also wear the special incubation vest for holding the samples pending shipment to the laboratory. The sampling teams must be well trained and organized to have the sampling equipment at the proper place and at the right time.

2. Equipment. Personnel collecting samples should be equipped with the same personnel protective equipment provided decontamination squads as outlined in D1.06. This equipment should include protective masks, hoods, and protective suits and impregnated gloves. As the protective suit is primarily for CW protection, little or no BW risk is involved by using the incubation vest in connection with protective clothing.

3. Area Assigned. Actual areas assigned to a single team (2 men and 1 kit) will vary with local conditions. For general planning, however, one team should be assigned to each 50 acres of built-up or developed section of a station such as a shop or waterfront area. It may also be desirable to have special teams for sampling water and food supplies.

4. Location. The sampling teams must have their equipment operating at the proper place and at the right time. As a part of the decontamination squads, they will report to the center when the station is alerted, and by the careful selection of locations for decontamination centers (see Figure 6), the problem of having a sampling team near the proper location is simplified. When sampling is to be a part of the regular routine during an air attack, the teams should prepare the sampling equipment when first reporting to the decontamination center. As soon as conditions permit, the teams should proceed to a suitable sampling location and set up the equipment.

B2.11 Shipment of Samples

Exposed membrane filters in the plastic dishes provided in the sampling kit may be suitably packaged for transfer to the laboratory without special processing. However, samples of filtrate for virus determination and suspicious objects

(especially dead animals) should be refrigerated. The field-sampling kit does not provide materials or equipment for this purpose. Packaging with dry ice is the preferable method. Thermos bottles and ordinary insulated bags similar to those designed for ice cream are satisfactory packages for the purpose. If dry ice is not available, "snow" from CO_2 fire extinguishers or CO_2 cylinders may be used as a substitute. While not as desirable, ordinary ice may also be used if dry ice is not available. Additional information regarding shipping instructions will be made the subject of directives from the various laboratories.

PART C. PROTECTION

Section 1. GENERAL

C1.01 Planning Protective Measures

Plans for biological warfare defense must be based not only on a recognition and understanding of what would be most desirable, or the ideal protection, but also on what is practical and feasible. The degree of protection to be provided depends on many factors that vary with the type, size, and location of individual structures and stations. Complete immunity and effective protection of everyone is the ultimate goal. The essential initial plans should be directed toward preventing disease-causing organisms from entering the body, either by means of individual protective equipment or by specially equipped shelters.

Although 100-percent protection of all personnel may not be feasible at this time, some protection for all personnel can be provided at every station with a minimum of cost. The defense measures presented here must necessarily be based on efforts to lessen rather than to eliminate risk. It is believed that by following the procedures outlined in this publication, the number of casualties for a biological warfare attack can be greatly reduced.

The complete doctrine of biological warfare and the details of passive defense measures have not been established; it is doubtful that any absolute rules of defense can be laid down prior to actual experience. Certain assumptions can be made, however, and definite protective measures can be taken. In specific instances, where it is demonstrated that these assumptions and measures are not applicable, they may be modified by suitable authority as the situation requires.

C1.02 Assumptions in Planning

The preventive measures discussed in this Part are based on the following assumptions:

1. That the entire station or local area will be contaminated.

2. That, in spite of this situation, there will be a noncontaminated area within a reasonably accessible distance, perhaps two miles.

3. That complete biological warfare protective shelters will be provided only for the following groups:

(1) Command and communications personnel
(2) Hospital and first-aid technicians
(3) Decontamination crews
(4) Disaster control crews
(5) Essential maintenance and utility crews

4. That there will be sufficient advance warning for personnel to mask and/or to take refuge in shelters that provide either full or partial protection against biological warfare. Shelters offering only partial protection will be provided for masked personnel to prevent gross exterior contamination of body and clothing.

C1.03 Function of the Public Works Officer

On the assumption that there might be a biological warfare attack at or near a naval establishment, the Public Works Officer, as directed by higher authority, should be prepared to support the following steps:

(1) Plan a definite course of action
(2) Provide necessary individual protective equipment and material
(3) In planning new permanent construction, provide for shelter components where no material increase in cost is involved

(4) Convert existing buildings or parts of buildings into protective shelters

(5) Build new structures for protective shelters

(6) Provide necessary decontaminating equipment and material

(7) Organize and train crews in protective procedures

Section 2. INDIVIDUAL PROTECTIVE EQUIPMENT

C2.01 Protective Masks

1. Description and Use. The protective mask and gas masks used for chemical warfare defense are also suitable for biological protection. The word "protective" in its present usage is synonymous with the previous use of "gas", but the latest mask carries the word "protective" in its nomenclature to show that it gives protection against all toxicological agents. Essentially, these masks provide a cover or shelter against the inhalation of harmful substances in the air. The Army lightweight service mask, M3A1-10A1-6, and the Army protective mask, field, M9A1 are currently in stock for issue to shore-based military personnel. (See Figures 3 and 4.) The MK4 and MK5 masks are issued to forces afloat only and are not discussed in this publication. Both the LWS and M9A1 masks are issued complete with carrier, facepiece, canister, antidim, and the M5 protective ointment kit. However, the M5 ointment is for use only against chemical agents and affords no protection against biological agents.

2. Limitations. The general limitations of gas masks are covered in this Bureau's publication, Chemical Warfare Defense, TP-PL-3. The following additional gas-mask limitations apply especially to biological warfare defense.

a. Facepiece. Because of variations in the size and shape of individual faces, some leakage around the edges of the facepiece may be expected. For protection against chemical warfare agents, this leakage is not serious; in the case of biological warfare, it may be serious. Therefore, an additional hood is required to protect personnel such as decontamination crews who are exposed to biological warfare agents for long periods. This hood is designed so that the exhaled air will maintain a positive pressure between the hood and the mask, thus preventing biological warfare agents from entering around the edges of the facepiece. (See Figure 5.)

Figure 3
Light Weight Service Mask

Figure 4
Army M9A1 Mask

b. Canisters. Military canisters are not exhausted or deteriorated by biological warfare agents. The external surfaces can be decontaminated and the canister reused in an emergency; however, undue exposure to biological warfare decontaminants does affect the canisters. Canisters offer only limited protection (approximately 30 minutes) against formalin vapors in concentrations normally encountered during biological decontamination. (See Part D.)

3. Storage. When not in use, protective masks should be stored in a clean, cool, dry, and well-ventilated place, free from fire hazards and vermin.

4. Inspection.

a. Carriers. Before masks are issued, the carriers should be inspected to detect any dirt, rips, tears, or worn places, and to assure that there are no missing components, such as antidim sets, snaps, and buckles. Items in the carrier that are not issued as part of the unit may be reclaimed.

Figure 5
Protective Hood With M9A1 Mask

Mud, grease, and soil may be removed from the carriers by vigorous brushing or by dry cleaning. If these methods are not practicable, the carriers may be washed superficially with soap and water. Carriers should not be laundered, however, because of the danger of shrinkage, which will make it difficult to replace the mask in the carrier. Laundering also has a tendency to remove the waterproofing compound.

b. Facepieces. After the carriers have been inspected, the facepieces should be cleaned and examined to detect any broken, scratched, loose, or missing eyepieces. Masks may be cleaned by washing them in soap and warm water after the canister has been removed. (See paragraph D6.03.) Damaged or missing lenses must be replaced prior to issue. The facepiece assembly may be inspected by distending, or flexing, the various component parts and noting any marked loss of resiliency in the rubber. Although there is no fixed test for determining the loss of resiliency, new masks may be used by inspectors as a standard for comparison in borderline cases. A visual inspection should be made for holes, cracks, and any sign of stickiness that may cause leaks in the rubber. All valves, valve guards, head harnesses, buckles, straps, deflectors, diaphragms, chin seams, angle tubes, tubes, and the hose of the facepiece should be carefully examined and repaired if necessary.

c. Canisters. The body of the canister should be examined for defects and any indication that the canister has been subjected to excessive moisture. If it appears that the canister body has been wet or damaged during storage, a new canister should be installed.

d. Repair Facilities. It is planned to procure for issue a repair and spare parts kit for each type of the currently available masks. The kit will have sufficient tools and spare parts to replace defective head harnesses and lenses and to repair minor breaks in the facepiece. Central mask-repair facilities are planned for making periodic inspection and major repairs to gas masks. When the plans for these facilities have been completed, the field stations will be advised of the procedure to be followed in effecting repairs that are beyond the capabilities of the individual station.

C2.02 Hoods

1. Chemical Warfare Hoods. The chemical warfare protective clothing currently being issued for decontamination teams has a jacket with a hood attached. These hoods are designed for use with the lightweight service mask, but they are not suitable for use with the M9A1 mask. When a gas mask

is not equipped with a hood, special care should be taken to assure the best possible fit of the facepiece to minimize leakage.

2. Separate Hoods. Procurement of separate hoods for decontamination teams to be used with protective masks is expected to be initiated in the near future. This item will be made of impregnated cloth similar to that shown in Figure 5. The hood is so designed as to utilize the positive pressure system referred to in paragraph C2.01. As soon as these units are available, the appropriate commands will be advised.

3. Improvised Hoods. When special hoods are not available, a temporary hood may be improvised from materials at hand; it should be patterned after the hood shown in Figure 5.

C2.03 Clothing

1. Description and Needs. In general, specially treated clothing will not be required for all personnel. Two layers of ordinary clothing, but preferably long underwear and outer garments and gloves, will be sufficient. Women should be equipped with men's clothes when it is known or suspected that a biological warfare attack is probable or imminent.

Decontamination crews, however, should be supplied with modified coveralls, that is, with extra legs and sleeves over the regular ones. These extra units should be made of material similar to the coverall proper and attached at the elbow and knee only. The outside sleeves and legs should be equipped with a drawstring or other suitable means of closing them around the wrist and ankles. Because a suitable protective coverall is not currently stocked, the proposed modifications will have to be made in the field on regularly stocked coveralls. However, efforts are being made to produce a protective uniform suitable for atomic, biological, and chemical defense.

2. Precautions.

a. Conventional Clothing. Special precautions should be exercised in regard to the clothing worn, such as shirts, trousers, field shoes, or combat shoes. Trouser legs should be pulled down to the ankle in two separate folds, one on each side of the leg, with the folds toward the back. If the trouser legs have ties, they should be secured firmly. They should also be tucked inside boot tops, or, in the case of field shoes, inside socks. If the trouser legs are too long, the excess should be arranged to blouse over the top of the socks or boots and not be turned up at the bottom.

All buttons should be securely fastened, starting with the bottom and working upward. All flaps must be smoothly and properly interleaved. Neck closures and cuffs should be securely fastened, with the tops of gloves drawn over sleeve cuffs to assure the best possible protection of the wrists.

b. Decontamination Clothing. Modified coveralls and gloves, impregnated if possible, and rubber boots should be worn by decontamination crews. The inside trouser legs and sleeves should be secured as for conventional clothing. The outside trouser legs should be rolled over the top of the boots and fastened at the ankles; the outside sleeve should be drawn over the gloves and fastened securely at the wrists. All precautions mentioned in regard to the wearing of conventional clothing should also be observed.

C2.04 Shoes and Boots

1. Types Required. Generally, the ordinary issue field shoes will be suitable for all personnel except decontamination squads. Leather shoes, however, should be as nearly waterproof as possible to prevent the entry of biological warfare agents with water leakage during rainy weather. Combat boots are more suitable than the regular field shoes because of the buckle top, which will hold the bottom of the trouser legs tight around the ankles.

Ordinary knee-length rubber boots are required for decontamination crews to protect them against the higher concentration they may encounter. Rubber boots have the additional advantage of being easily decontaminated.

2. Maintenance. It is evident that, after an initial cloud settles, the greatest concentration of agents will be on the horizontal surfaces where people may have to walk. Blisters, cracks, and other openings on the feet may serve as a point of entry of biological warfare agents and may result in infection. It is important, therefore, that shoes be kept in good repair and continually treated with dubbing or other waterproofing materials to limit the possibility of contamination of persons in the area. Rubber boots also must be kept in good repair to reduce the possibility of contamination through breaks or holes.

3. Limitations. The field-type leather shoes do not provide 100% protection and therefore should not be worn for extended periods of time in areas known to be contaminated.

Although rubber boots afford good protection, they are uncomfortable if worn for extended periods, particularly in

warm weather.

4. Precautions. The same care must be taken in removing either shoes or boots as is required in handling any other contaminated items, such as gloves and masks. The best procedure to follow is to sit on a bench, remove the shoes on one side, being careful not to touch the ground with the feet, pivot on the bench, swing around to the clean ground on the other side, and then proceed to remove the remainder of the clothing.

5. Decontamination. After exposure to biological warfare agents, field shoes and rubber boots may be decontaminated with ETO (ethylene oxide) or chlorine solution. (See Part D, Section 6.)

Section 3. PROTECTIVE SHELTERS

C3.01 Planning

In planning for personnel protective shelters, consideration must be given to the following possibilities:

(1) Converting all or a part of existing facilities into protective shelters

(2) Building new single-purpose structures

(3) Designing new construction to facilitate later conversion to personnel protective shelters

The principles outlined in this section are general and may be applied well to any one of the three plans regardless of the type of building to be used as a shelter.

C3.02 General Considerations

1. Location. Shelters should be located as close as possible to where personnel are likely to be at the time of warning. The route to the shelter should be clear of obstructions, such as stocks of materials and parked equipment, and it should not extend through narrow passageways that would limit free passage through the entrance. If possible, shelters should be adaptable to gasproofing and pressurizing and have no glass in the walls.

2. Pressurizing Shelter Areas. The primary consideration in preparing shelters for protection against biological

warfare aerosols is to prevent the entrance of aerosols. This may be safely accomplished by pressurizing continuously, that is, by introducing filtered air to maintain a slight positive pressure. If the shelter is reasonably gastight, all minor leaks will be outward. Obviously the less air leakage there is, the easier it is to maintain a safe pressure. When a shelter location is being selected, therefore, consideration should be given to the feasibility of providing protection by pressurizing. Methods of reducing the leakage are discussed in paragraph C3.08.

3. Arrangement. The essential components of a shelter area include air locks, toilet facilities, and a waiting area. If contaminated personnel are to use the shelter, then additional areas will be required for undressing and disposing of contaminated clothing, preferably in the air locks. A location just inside the shelter, and upstream from the air lock, will be required for the removal and disposal of gas masks and a shower area for personnel decontamination. If both male and female personnel are to use the same shelter, duplicate air lock, shower, and toilet facilities will be required.

If the shelter is to be used only as a place for personnel to assemble during an alert, the undressing and decontamination facilities may be omitted. It should be remembered, however, that such an arrangement precludes the possibility of later admitting anyone into the shelter who might be contaminated.

Although there is no established pattern for arranging the facilities of the shelter, the layout should assure an individual's progress from the outside through the air locks to the decontamination rooms and into the clean area.

Figure 6 is a suggested layout of a complete pressurized shelter. Duplicate toilet and showers are not shown.

4. Capacity. The air supply will generally control the capacity of a shelter area. For active personnel, from 7 to 10 cu ft of air per minute should generally be supplied for each person, the amount varying with the temperature, humidity, and space conditions. This quantity of air is satisfactory if 350-500 cu ft of space is also provided.

Table 1 shows the effect on persons of various conditions of humidity, temperature, and oxygen content of the air. Table 2 shows the capacities of different types of ventilated shelters supplied with filtered air from a

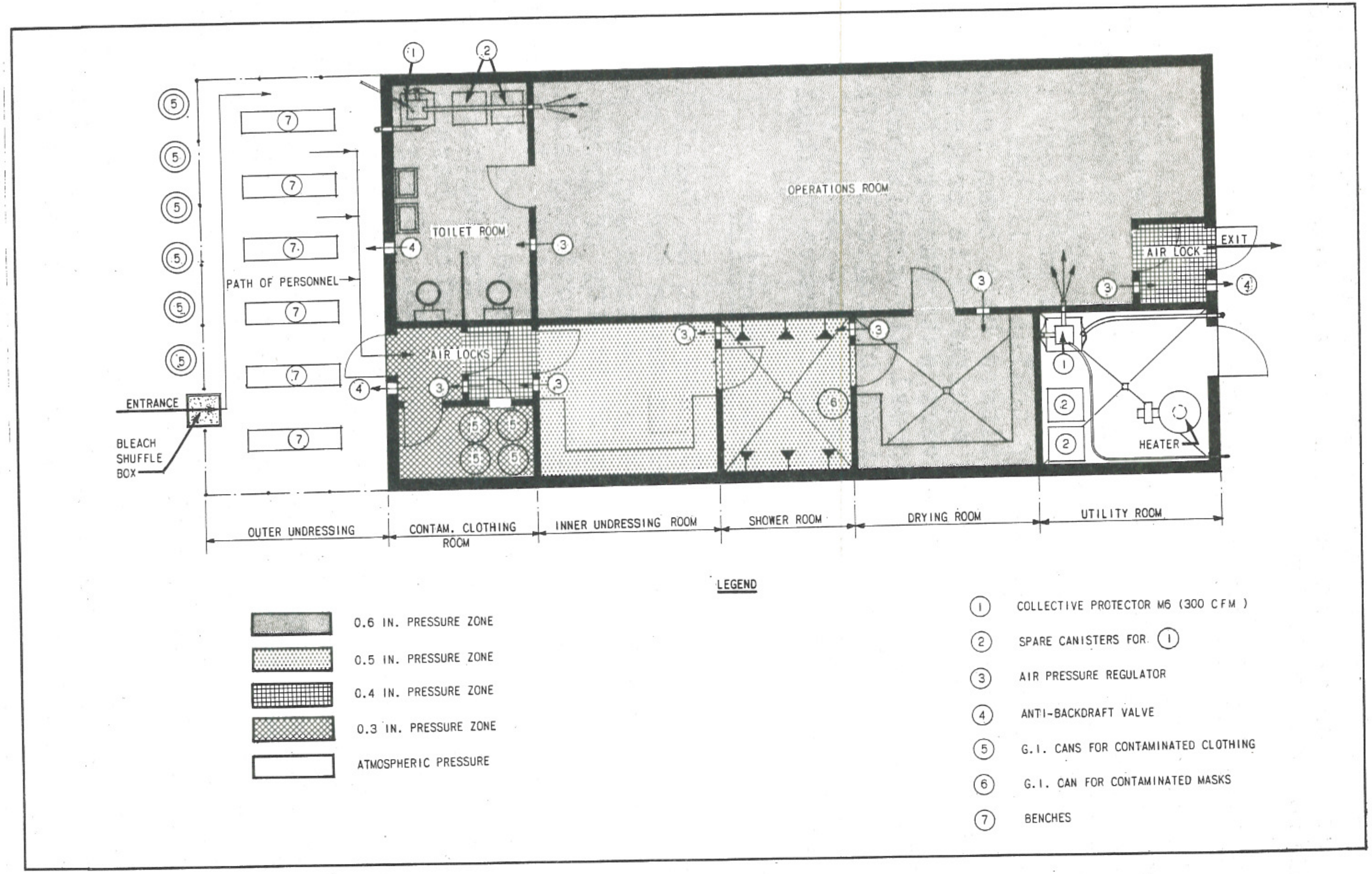


Figure 6
Suggested Layout of BW and CW Defense
Station for Decontamination Squads

standard M6 collective protector. Table 3 indicates the capacities of unventilated shelters and the air requirements under different conditions.

C3.03 Conventional Air Conditioning Equipment

In general, air-conditioning or ventilating equipment in permanent or temporary buildings used as shelters should not be operated during a biological warfare attack, or for several hours thereafter; however, this equipment may be operated if it is specially fitted with efficient filters to remove the pathogenic agents or toxins or if the outside air intakes are sealed. If such filters have been installed and the building served by the equipment is properly fitted (see C3.02), the area will be very satisfactory for group protection. Filters used in normal air-conditioning equipment are of doubtful value against biological warfare agents and reliance should not be placed on them until it has been positively determined that they will remove biological agents.

C3.04 Partial Biological Warfare Protection

1. During an Attack. It may not be feasible to completely seal or protect shelter areas for all personnel of a station. However, limited protection can be provided in most cases by reducing the probability of gross contamination. This can be accomplished by providing shelter space where the major openings have been protected. In this type of shelter it may be expected that some aerosol will enter through minor cracks and openings into the shelter. This aerosol will represent a serious respiratory hazard; consequently, occupants must wear gas masks. Every effort must be made, therefore, to seal unventilated shelters as securely as facilities will permit. The use of heavy cloth, such as draperies, securely fastened over doors and windows will materially decrease the amount of aerosol that can enter the area. If the area is reasonably well sealed, the aerosol that does penetrate will be finely dispersed and very little will settle on clothing, thus greatly reducing the hazard of secondary infection from clothing.

Filter paper banks may be placed in the one wall of the area. Because of their cost and fragility, however, these filters are not generally recommended. The arrangement prevents the aerosol from penetrating the filter but permits fresh air to be diffused or wafted through it. Nevertheless, unless the area has previously been extremely well sealed, gas masks would still be required.

Shelter areas that are not equipped with powered (mechanical) ventilation may become unpleasant during

Table 1

Effects of Temperature, Humidity, Oxygen, and CO_2 on Humans

Condition of air				Effect
Temperature (degree F)	Relative humidity (percent)	Oxygen (percent)[1]	CO_2 (percent)[1]	
70-75	50-70	21	0.03	Comfortable conditions in normal shelter
85	90			Acute discomfort, faintness, and a feeling of suffocation and alarm
92	90			A dangerous rise in body temperature, pulse, and rate of breathing, accompanying panic
98	95-100			Rapid rise in body temperature conditions, extremely dangerous
		Reduced to 14		Not harmful
		10	0.6	Limits for normal breathing
			Up to 1.5	Quite innocuous
			3	Practical limit of safe occupancy
			4	Physiologically undesirable; lung action increased to three times normal
			5	Dangerous!

[1]Effects at any temperature and humidity.

Table 2

Maximum Allowable Number of Men in Ventilated Emergency Shelters for Each Standard M6 300 cfm Collective Protector

Type of shelter	Number of men			
	Outside air below 90° F		Outside air above 90° F	
	Performing light duties	Completely at rest	Performing light duties	Completely at rest
Underground or above-ground shelters with walls of low heat conductivity[1]	75-150	200-250	60-80	150-200
Above-ground shelters with walls of high heat conductivity[2]	99-200	200-250	75-150	150-200

[1]Walls of wood or dry earth have low heat conductivity.

[2]Walls of metal, concrete, masonry, and damp earth have high heat conductivity.

Note: High heat or high relative humidity decreases the number of persons that a shelter will accommodate.

Table 3

Minimum Cubage Requirements in Unventilated Emergency Shelters (For occupancy period of 3 hours)

Type of shelter	Capacity (number of men)	Cubic feet of space per person			
		Outside air below 90° F		Outside air above 90° F	
		When completely resting	When performing desk work	When completely resting	When performing desk work
Underground or above-ground shelters with walls of low heat conductivity[1]	1-10	200	360	240	500
	10-25	300	540	360	725
	25-50	400	750	500	1,000
Above-ground shelters with walls of high heat conductivity[2]	1-10	150	270	180	360
	10-25	235	425	270	540
	25-50	300	540	380	720

[1]Walls of wood or dry earth have low heat conductivity.

[2]Walls of metal, concrete, masonry, and damp earth have high heat conductivity.

occupancy, but it is not anticipated that the lack of oxygen or the increase of carbon dioxide will be dangerous if minimum space requirements are provided.

2. Continuous Protection with Electrostatic Precipitator. It was assumed in paragraph C1.02 that there would be sufficient advance warning for personnel to mask and/or take refuge in shelters. This assumption, of course, may not always be valid because the warning system may not be adequate or a covert attack may have occurred. It may be desirable, therefore, to provide continuous protection to selected parts of a facility. Because of the cost of operation and maintenance, it may not be practical to operate a blower filter unit continuously to provide that protection. Neither can personnel work for extended periods of time in gasproof shelters not equipped with power ventilation.

Although electrostatic precipitators may not afford 100% protection against any degree of biological warfare and radiological warfare attack, they may reduce the hazard from a light attack to a point within the tolerance of most personnel. No chances, however, may be taken; as in the case of the other type of partial protection, gas masks will be required for personnel during and immediately after a known or suspected biological attack. Electrostatic precipitators, however, are not effective against chemical agents and therefore will have limited application in an over-all protective shelter program where all types of attack must be considered. A negligible quantity of power is required for the operation of electrostatic precipitators because of the low resistance across the units.

When the room is practically gasproof and all of the incoming air is directed across a precipitator, approximately 99.5% or more of the pathogenic agents or other particulate is removed. The precipitator referred to here is not the standard commercial device that is usually 85 to 90% effective, but is a device specially modified in accordance with principles developed at the Naval Research Laboratory. (See C3.06.)

C3.05 Complete Biological Warfare Protection

1. Forced Ventilation. To afford complete protection against a biological warfare attack a shelter area must be specially sealed. (See C3.08.) For extended periods of occupancy, it would be necessary then to provide fresh, clean air to the area by means of an electrically operated or gasoline-powered blower, equipped with suitable filtering devices. Occupants of this area would not need to wear gas masks, and there would be no later danger of infection by secondary

aerosols from clothing and equipment. If personnel must enter or leave the shelter during an attack, an air lock will be required.

2. Nonpowered Ventilation. A tightly sealed room or an area with a part or all of one wall constructed of filter paper banks will offer nearly complete biological warfare protection for a limited time only. The filter paper bank, however, must be adequately protected from blast effects. This shelter will give complete protection provided the occupants enter the shelter before the attack. No means for entering or leaving the shelter during the attack can be readily provided. Because no air is forced through the filter, no power is required. This no-power shelter will obviously be less comfortable than the one providing fresh air.

C3.06 Protective Shelter Equipment

1. Blowers. The selection of a particular motor-blower unit will depend on the air flow-pressure drop characteristics of the air-cleaning device being used. These characteristics are specified for each such device that is manufactured. The Army Collective Protector, M6, is an air-cleaning device that is available complete with motor-blower unit.

2. Paper Filters. Paper filters, arranged in suitable frames, have been developed by the Army Chemical Corps. The filters are:

Filter	Outer dimensions	Capacity (cfm)	Air resistance (inches of water)	Weight (lb)
M1	8" x 8" x 3 1/16"	15	0.7-1.0	1 7/8
M2	8" x 8" x 5 7/8"	30	0.7-1.0	3 1/2
M3	24" x 24" x 3 1/16"	150	0.7-1.0	14 3/4
M4	24" x 24" x 5 7/8"	300	0.7-1.0	24 3/4
M5	24" x 48" x 5 7/8"	600	0.7-1.0	46
M6	24" x 24" x 11 1/2"	600	0.7-1.0	46
M7	24" x 30" x 11 1/2"	600	0.8-1.3	57 1/2

These filters are provided with the Army Chemical Corps Type 6 filter paper. They are not, however, currently stocked for issue to shore activities. When properly installed in suitable ducts, these filters offer complete protection against biological and radiological warfare agents, but they give no protection against toxic gases. However, the Army Collective Protector, M6, equipped with both the charcoal and particulate filters, gives adequate protection against all known toxic aerosols and gases, and its rated capacity is 300 cfm.

3. Electrostatic Precipitators. The electrostatic precipitators that are most effective against biological warfare agents are manufactured by the Westinghouse Electric Corporation and others. The units currently available are as follows:

Model	Outer dimensions	Capacity (cfm)	Air resistance (inches of water)
V-22*	25 3/4" x 23 3/4" x 34 1/2"	1,000	0.1
V-42*	25 3/4" x 47 1/2" x 34 1/2"	2,000	0.1

*NRL Modified.

When these units are procured commercially, the order should specify an efficiency of 99.5% or more.

4. Other Devices. The use of ultraviolet radiation, various glycol mists and vapors, and ozone for the protection of personnel in shelters, in the event of an attack, is not considered practical and is not recommended at this time even though these methods may offer adequate protection under certain specialized conditions.

C3.07 Gasproofing Shelters

To gasproof the shelter, all cracks around floor joints, pipes, and conduits leading to the outside of the shelter should be tightly calked with putty, cement, or bituminous mastic and then covered with a heavy coating of varnish. Walls and ceilings can be plastered, if necessary, to assure air-tightness. As an expedient, one or two layers of paper may be pasted over the walls and then covered with a heavy coating of varnish.

Windows should be sealed shut, calked, and provided with shutters; in addition, gastight curtains should be provided for protection in case any of the windows are broken. Windows and doors that must be opened periodically should be tightly weather-stripped. When normal operations require the use of entrances, other than those through air locks, hatches, heating, or ventilating ducts, or other openings into a shelter, the openings should be equipped with removable covers fitted with weather-stripping or rubber gaskets and positive locks so that they can be rapidly closed, sealed, and locked in case of attack. The outside face of concrete walls may be given a cement wash.

Gasproofing by means of spraying plastic over the interior surfaces may also be found practical for this purpose. (See D5.06.)

C3.08 Air Locks

1. General. Entrances to a shelter should be protected by a two-compartment air lock. (See Figure 6.) A suitable air lock can be formed by a walled-in, gasproofed passageway extending several feet inside and outside of the walls of the shelter proper. Outside entrances of the air lock should be on the prevailing downwind side of the shelter.

2. Doors. Doors should be located in the passageway a sufficient distance apart to permit undressing and to make it impossible for anyone passing through the air lock to operate two doors at the same time. If the shelter entrance is a simple, horizontal passageway, the doors should be from 6 to 9 feet apart. If the shelter is to serve as a first-aid station, the space between the doors should be large enough for personnel to move a stretcher through the air lock without having to open both doors at the same time. Where the entrance to the shelter is a stairway, a door may be placed at the head of the stairway and one at the foot to form an air lock, provided there is a horizontal passageway extending several feet at the bottom of the stairs. It is not desirable to have doors located on the stairway.

3. Ventilation. If the shelter is ventilated, some air should be exhausted through the air lock to remove contamination. Approximately 100 cu ft of air per minute through a double air lock will remove chemical agents in one minute, while 200 cu ft of air per minute for 5 minutes will be required to remove both chemical and biological agents. Air deflectors or baffles may be required in the air lock to assure the effective removal of contamination.

Until a publication on the conversion of existing facilities to protective shelters is issued by the Bureau, the Department of the Army Technical Manual, TM 3-350, Gasproof Shelters, may be referred to for the design and installation of air controls.

C3.09 Comfort and Storage Facilities

1. Water. Where protective shelters are to be used for personnel decontamination, bathing and washing facilities will be required, with one shower head for each 10 persons expected to occupy the shelter. Warm water at approximately 80° F or higher is desirable for showers. The floor of the washing area should be constructed with drains, equipped with deep-type traps, to remove the wash water as rapidly as possible. A manually controlled, chain-operated valve should be installed on showers to conserve water.

A minimum auxiliary supply of canned drinking water, amounting to one quart for each person, should be provided in the shelter.

2. Lights. Facilities for lighting should be consistent with the intended use of the shelter; however, reduced lamp wattages are desirable, to decrease heat radiation. Auxiliary lighting, such as battery-operated electric lanterns, should be supplied for use in the event of power failure.

3. Seats. Sufficient seating capacity should be devised to accommodate all personnel for whom the shelter is intended. Long benches may be used to reduce space requirements.

4. Toilets. Toilets without outside ventilating pipes should be provided in the ratio of one for every 40 occupants. The chemical type may be found desirable.

5. Storage. Space will be required for the storage of gasproof curtains and other equipment; soap and towels for washing; and putty and other materials for repairing holes and cracks.

C3.10 Selection of Type of Shelter

The shelters selected to provide some protection for all personnel at a station would include two types: shelters for evacuated personnel and shelters for resident personnel.

1. Shelters for Evacuated Personnel. A shelter area should be provided for personnel who can leave the station after an attack. The minimum requirements would be a structure, or portion of a structure, in existing buildings that would provide the best available protection from blast and, at the same time, offer protection against gross contamination from chemical and biological sprays. Although large openings should be covered with blankets, curtains, or other expedient means, persons would be required to wear masks for protection from aerosols seeping into the shelter area. No provision for personnel decontamination would be necessary for this type of shelter because personnel could leave the contaminated area in masks and be decontaminated later.

2. Shelters for Resident Personnel. Centers that must operate for extended periods, or that can not be operated by personnel in masks, such as command, communications, decontamination, and first-aid stations, will require shelters that provide 100-percent protection against radiological, chemical,

and biological warfare agents. Provision for this degree of protection does not necessarily mean the large expenditure of funds or extensive modifications of buildings; 100-percent protection can be effected by providing the following facilities:

(1) An area in a building that will afford the best available blast protection.

(2) A gasproof area, sealed by using weatherstripping around doors, windows, and other openings that must be opened during normal operations; and by closing cracks with tape, spraying with plastic, or applying heavy coats of varnish or cement washes.

(3) An air lock. In case a permanent air lock would interfere with the normal use of the area, a portable lock could be fabricated and installed when required.

(4) An all-purpose type of collective protector, that is, one with a particulate filter for biological and radiological warfare and a charcoal filter for chemical warfare protection.

(5) Chemical toilets if other types are not in the proposed area.

(6) Some personnel decontamination equipment or facilities. If the installation of showers is not feasible, personnel may wash with alcohol.

(7) Auxiliary power sufficient for emergency light and blower operation.

C3.11 Protection Against Sabotage

It is difficult to include sabotage under the assumptions made in paragraph C1.02 or to plan many specific protective measures against it. It is not considered probable that a biological warfare saboteur would be active during a general air raid by an enemy. Instead of spreading toxic agents at this time, however, a saboteur might choose to render collective shelters inadequate by destroying certain air seals of the structures, by puncturing the paper filters, or by disconnecting power to electrostatic precipitator plates in preparation for a subsequent covert attack with pathogenic agents. These acts of sabotage would not be apparent by casual inspection, or by operation of the equipment. Therefore, adequate security measures, such as making periodic tests

of performance, must be taken to protect the shelters.

Section 4. PROTECTION OF WATER AND FOOD

C4.01 Methods of Attack

1. Aircraft. Biological warfare agents may be placed in a drinking water supply by enemy aircraft in open warfare or by saboteurs. The operation of enemy aircraft in contaminating a water supply could be masked by a simultaneous enemy air attack with high explosives or other bombs. It is probable that only large reservoirs would be subjected to such a biological warfare attack from the air.

2. Sabotage. It is more probable that an enemy will resort to sabotage in contaminating a water supply, with operations directed against the water distribution system. The water distribution system may be very vulnerable to sabotage, particularly where there are hydraulic weaknesses, open-treated-water reservoirs, poorly protected vital structures, or inadequate disinfection.

C4.02 Quantities Required for Contamination

It should not be assumed that a large quantity of material will be required to contaminate a water supply system. Evidence that small doses of biological warfare agents may be dangerous is suggested in the work of R. W. Kehr and C. T. Butterfield, in Public Health Reports of April 9, 1943, "Notes on the Relation Between Coliforms and Enteric Pathogens." The conclusion reached by them is that the ingestion of a single typhoid organism might cause illness in one percent of the population. It should be assumed, therefore, that logistical problems will not deter the saboteur.

C4.03 Types of Probable Agents

It may be expected that the agents that would be of particular interest to an enemy would be those not commonly considered to be the water-borne type; against such agents, defenses have not yet been made completely effective. However, we should not eliminate the possibility that the enemy would use the common intestinal pathogens and, by clever manipulation, penetrate our normally dependable defenses. Moreover, the enemy might use several agents simultaneously to confuse our attempts at detection and to delay or mislead any medical diagnosis of resulting illness. Every defensive tool, therefore, must be examined and strengthened in order to cope with the threat of biological warfare against our

drinking water supplies.

C4.04 Need for Strengthening Normal Detection Procedures

As far as known, no organized attempts have been made to introduce biological warfare agents into drinking water supplies. However, pathogens frequently enter our water supplies under natural conditions, and effective methods have been developed to detect and destroy them before the water is consumed. The deliberate contamination of a water supply by an enemy must be combatted by strengthening the defenses established against natural contamination. Protection of the physical structure of the water works system must be extended and reinforced; laboratory procedures must be modified or augmented so that pathogens in water may be rapidly detected and identified; and water treatment operations must be conducted on the highest level of efficiency.

C4.05 Protection of Water Works System

1. Vulnerable Areas. The vulnerability of the water works system to biological warfare attack must be carefully studied, and protection of important locations must be coordinated with security forces. Among the most critical water works structures, from the standpoint of defense against biological, as well as chemical and radiological, warfare are these: unprotected transmission or mains to target areas; water service lines directly connected with these mains; valve chambers, automatic pumping stations, and booster chlorination stations that may be used as hidden work locations by the saboteur; and open reservoirs and other locations of water storage that could be reached easily by a saboteur.

2. Protective Measures. Whenever possible, critical structures should be improved to reduce their vulnerability. Such improvements might include automatic burglar-type alarms at hidden work locations, backflow preventers in certain service connections to important transmission mains, and automatic signal devices to give an appropriate alarm whenever an abnormal flow condition exists in such service connections. An automatic signal device activated by the absence of free chlorine residual would obviously be useful at critical locations in the water supply system.

Vulnerable structures must be protected by adequate policing. In this connection, it is important that protective action be taken against enemy agents who pose as employees of the water works. The Public Works Officer should seek the cooperation of the security force in the identification of every person who engages in any work involving a structure of

the water works system, particularly volunteers.

C4.06 Laboratory Examination of Water

1. Function of the Laboratory. The minimum role of the laboratory in defense against biological warfare will be to confirm epidemic intelligence findings that an attack has occurred. An outbreak of disease that exhibits the normal characteristics of water-borne outbreaks may actually be the first indication that a successful enemy attack has been made through a water supply system. Obviously, such confirmation has an important bearing on the further protection of target personnel. If detection and confirmation can be accomplished in a matter of hours, a warning could be given in time to protect a large number of persons.

2. Problems. The laboratory examination of water samples is an essential procedure in detecting an attack with biological warfare agents. However, certain fundamental problems are encountered in this work. A basic difficulty is the possibility that the sampling schedule, even though it is intensified to the limit of the laboratory's capacity, might fail to collect samples during the period and at the location of biological warfare agent contamination. A second difficulty is the possibility that the pathogen may be foreign to water laboratory experience. Another problem in rapid detection is the time lag inherent in the collection, transportation, and examination of samples. These difficulties and problems are not new in the routine water laboratory experience; although they may reduce the effectiveness of the laboratory in detecting agents, they should not deter the Public Works Officer from using the full resources of the water laboratory in providing the best possible protection.

3. Present Methods. Our present methods of water analysis are not adequate for detecting a biological warfare attack against a water supply. Disease-producing agents introduced into the water supply, either openly or by sabotage, would probably not be accompanied by coliform organisms, which are the normal indicators of water contamination. In such cases, our standard methods of water examination might give no indication of the presence of a biological warfare agent.

C4.07 Use of Chlorine as a Protective Measure

1. Concentration. The maintenance of free available chlorine at the highest feasible level throughout the system is the most satisfactory single measure for protecting the water supply. However, the chlorine residuals ordinarily

found to be protective against accidental contamination of the supply may be inadequate for protection against deliberate enemy action. Also, it is not possible to say definitely what concentration constitutes a safe level because the chlorine demand of the biological warfare agent preparation that the enemy might use is obviously not known. Therefore, the maximum concentration of free available chlorine consistent with palatability should be maintained. This will mean the reinforcement of chlorination capacity for many installations, particularly those in critically important locations.

2. Continuous Decontamination. In practice, the protection of water includes a process of continuous decontamination. Under normal conditions this is accomplished by the introduction of sufficient chlorine to effect a free available residual of 0.4 ppm for at least 20 minutes. If it is suspected or demonstrated that unusual pathogens or toxins are present in the water, it will be necessary to increase the residual and lengthen the contact period. This process is discussed in Section 7 and will not be covered here. Ample stocks of chlorine should be kept on hand for use in the event of an intentional contamination of the water supply.

3. Chlorination at the Station. It is possible that water that has been originally chlorinated at the source of supply may become contaminated en route as the result of sabotage or other method of attack. If conditions at any station are such that this situation could prevail, it is recommended that some provision be made for chlorination at the point where the distribution lines enter the station. Even if the actual equipment is not readily available, taps should be made so that there will be no delay in hooking up field chlorinator units if an emergency should arise.

C4.08 Auxiliary Water Supply

1. Wells. Other measures should be taken to assure the availability of safe water in the event of a biological warfare or other form of attack. It is recommended that a second source of water be provided if possible, preferably a deep well located on the station proper. For local consumption, this auxiliary supply will not need to be great. The well should be equipped with an alternate source of power to be used in the event of electric power failure. Because a well may be very difficult for a saboteur to contaminate, it may provide a reasonably sure source of safe, potable water even in case of a biological warfare attack, provided the well and its companion storage facility are adequately covered and guarded.

2. Uncontaminated Areas. It is far better to provide an emergency, noncontaminable source of water supply than to plan any decontamination countermeasures that would have to be forced into operation by a biological warfare attack. For this reason, the possibility of hauling potable water from noncontaminated sources should be considered, even though the distance may be considerable.

3. Canned Water. Potable water should be stored in shelters in covered vessels, such as 5- or 10-gallon milk cans, if a biological warfare attack appears imminent. This water may be augmented by canned water, Navy Stock No. G23-W-75, for long-time storage to be utilized in an emergency. Iodine tablets should be provided in the event of persistent or recurring attacks.

4. Precaution. Emergency water normally will be located and dispensed within the protective shelters. Obviously, when the atmosphere is contaminated, the removal of the mask in order to drink can not be permitted.

C4.09 Protection of Food

1. Importance. It is particularly important to protect food from contamination, especially where supplies are not easily replaced. Furthermore, the decontamination of food is usually difficult; and even when it is successfully decontaminated as far as biological warfare agents are concerned, the palatability of the food is often impaired to such an extent that it is not edible.

2. Storage. The storage of food in protected areas is the practical method of protection for most installations. The gasproof chamber is the only storage facility that will provide 100-percent protection for large quantities of food, but the cost will probably preclude any extensive use of that type of protection for food. Unpacked food in galleys and food in open or unprotected packages may be kept in cans or bins with gasproof lids. Refrigerators provide excellent protection.

When food is stored in more than one building, it may be desirable to select an area that offers the best protection for foods that are most easily contaminated, such as foods that are not packaged or are in packages affording little or no protection. Foods in cans and bottles, which require the least protection, can be stored in a partially protected area.

Food that is kept in the open or in partially enclosed buildings may be covered with tarpaulins or other protective

covers. Although covers will not prevent contamination from a biological warfare aerosol, they will reduce the amount of contamination that reaches the packages.

3. Sabotage. The problem of protecting food from saboteurs, which is considered outside the normal responsibility of the Public Works Officer, is not covered in detail in this publication. (See Section 8 of Part D.) Bakeries and ice cream plants are particularly vulnerable points. Foods that are obtained locally or from nonmilitary sources might constitute perfect media for biological warfare sabotage activities.

PART D. DECONTAMINATION

Section 1. INTRODUCTION

D1.01 General

Various methods of destroying disease-causing organisms (pathogens) have been developed on a limited scale over a long period of time. Because of the cost, lack of materials, and time required to take effect, many of these methods are not applicable to the large-scale decontamination operation that would be required in case of a biological attack.

D1.02 Decontamination Materials

Investigation shows that five materials that are available to the Public Works Officer are suitable for use as large-scale decontaminating agents. These agents are:

(1) Vapors of formalin (formaldehyde-water solution)
(2) Ethylene oxide gas
(3) Carboxide gas (mixture of ethylene oxide and carbon dioxide)
(4) Chlorine, applied as bleach slurry or other form that will release free chlorine to the contaminated area
(5) Lye in solution

D1.03 Limitations of Decontaminants

Each of these materials has certain characteristics that limit its effectiveness when used as a decontaminant.

Formalin vapor will not penetrate into tightly closed places; this characteristic, however, makes it a desirable decontaminant for spaces that are impractical to gasproof before decontamination, such as building interiors.

Table 4

STANDARD CHEMICALS SUITABLE FOR BIOLOGICAL DECONTAMINATION

MATERIAL	APPLICATION	LIMITATION	PACKAGE AND STORAGE	REMARKS
Formaldehyde Solution (Formalin) diluted with equal parts of water	Applied as a vapor by heat, high-pressure spray devices, paint-spraying equipment, or bubbling steam through pan of material. Approximately 2 qts of dilute solution per 1,000 cu ft above 70° F; double amount for each 20° drop below 70° F. Vapor allowed to remain 16 hours in a closed structure. Ideal temperature between 70° and 80° F and relative humidity of 85%. Gasproof sealing of room not required. However, major openings must be sealed.	Vapors highly toxic to personnel. Vapors of pure formaldehyde are flammable. When steam is used to vaporize, source of steam should be outside area being decontaminated. Formalin will not penetrate cloth and similar material as effectively as some sterilizing gas. Open flame not suitable for vaporizing. Decontamination below 40° F not advisable. May cause some damage to delicate instruments and dampness may curl and ripple paper. Rubber gloves or protective agents required to cover skin of handlers. Even with forced ventilation, building requires 24 hours aeration to be usable. Vapor polymerizes and deposits white powder on horizontal surfaces. This powder may be washed up with hot water. Ineffective against dried botulinus toxin.	Available from general stores in 55-gallon drums. Care must be exercised to prevent leakage while in storage.	1. Personnel should wear masks when handling this solution. Once the vaporization has started, even persons wearing masks should not enter area until process is complete in an emergency.

Table 4

STANDARD CHEMICALS SUITABLE FOR BIOLOGICAL DECONTAMINATION (Continued)

MATERIAL	APPLICATION	LIMITATION	PACKAGE AND STORAGE	REMARKS
Ethylene Oxide	Expose the contaminated equipment to ethylene oxide vapor under a gas-proof tarpaulin for 6 hours at 75° F. If gasproof tarpaulin is used, edges should be sealed by placing in a trench and covering edges with earth. (See note 2 under Remarks.) 30 lb ethylene oxide for each 1,000 cu ft above 75° F. For each 20° drop in temperature double the preceding amount is required. Gas is highly penetrating and non-corrosive.	Requires gastight enclosures to be effective. (See note 2 under Remarks.) Gas highly explosive in suitable mixtures of air. For this reason, it is not suitable for use in buildings. Toxic to personnel if improperly used. When ground under gasproof cover is wet or extremely porous, a protective cover over the ground is required. Decontamination below 50° F is not advisable. Liquid will damage plastics or leather. Ineffective against dried botulinus toxin.	3-lb ETO cylinders are available commercially. Must be stored away from fires. Cylinders should be protected from rough handling and sparks.	1. Since ethylene oxide is very toxic and flammable, it must be used only by competent personnel and in such a manner as to protect other individuals. Personnel subject to concentrated vapors should use masks. 2. No gasproof tarpaulins available in stock. Ordinary tarpaulins may be suitably treated with heavy coating of vinyl plastic.
Carboxide	Expose the contaminated equipment to carboxide gas in the same way as ethylene oxide except contact period is increased from 6 to 24 hours. A gasproof chamber is necessary, and a tight seal is necessary when a building is used as an improvised chamber. The chamber selected for gas-proofing should be as small as practicable to conserve gas and be free of air ducts, power panels, roof ventilators, or utility control valves. A suitable chamber can be formed by spraying inside of a room with strippable plastic. 60 lb of carboxide for each 1,000 cu ft above 80° F. For each 20° drop in temperature, double the preceding amount.	Requires gastight enclosure to be effective. Gas is not explosive in suitable mixtures of air. For this reason, it is suitable for use in buildings. Toxic to personnel if improperly used. Decontamination below 50° F is not advisable. Carboxide is not corrosive. Cylinders do not require heating to release gas at suitable rate. Ineffective against dried botulinus toxin.	Available from general stores in 60-lb cylinders.	1. Carboxide in liquid form is a mixture of ethylene oxide and carbon dioxide. One lb liquefied gas is equivalent to 8.8 cu ft free gas at normal temperature and pressure.

Table 4

STANDARD CHEMICALS SUITABLE FOR BIOLOGICAL DECONTAMINATION (Continued)

MATERIAL	APPLICATION	LIMITATION	PACKAGE AND STORAGE	REMARKS
Compounds containing available chlorine: Calcium hypochlorite (HTH used in water purification) STB bleach (chemical warfare) Grade 3 bleach (chemical warfare) Sodium hypochlorite (ordinary household bleach)	Slurry, for use on vertical surfaces. Prepare slurry of 40 parts bleach and 60 parts water by weight. Apply with 400-gal power sprayer. Average coverage: 1/8 gal per sq yd. Clear solutions having free chlorine of about 2% are suitable for horizontal surfaces. For STB bleach, a mix of 7 parts bleach to 93 parts water is suitable. Ordinary household bleach (half strength) sprayed on surface with M1 3-gal or 400-gal chemical warfare decontaminating apparatus. Horizontal surfaces should be treated with 1/8 gal per sq yd for concrete and 1/2 gal per sq yd for compacted earth. Mechanical agitation improves effectiveness. 1/2 percent detergent required in any of the solutions.	Bleach is very corrosive to metals. Continued absorption through skin and breathing is harmful.	STB or Grade 3 bleach shipped in 8-gal, 50-lb containers. Under ordinary conditions, loss of available chlorine in bleach is less than 1% per month. When free chlorine has fallen below 10%, bleach should be salvaged. HTH does not store well at elevated temperature. Frequent inspections are necessary to remove containers that have deteriorated or started to "heat". Store in unheated warehouse isolated from combustibles and metals subject to corrosion.	1. Whenever bleach slurry is used in decontaminating apparatus, antiset in proportion of 1/2 lb antiset to 100 lb bleach must be added. 2. Personnel must wear masks when working with the solutions.
Sodium Hydroxide (caustic soda or lye)	(Used as 10% solution by weight). Average application 1/8 gal per sq yd on horizontal surfaces.	Highly toxic to personnel. Highly corrosive and will damage fabrics.	Solid caustic soda is stored in iron drums that are sealed to keep moisture out and prevent absorption of carbon dioxide from the air. Caustic soda solution may be kept in iron, steel, or glass containers equipped with rubber stoppers wired or taped in place when not in use.	1. Solution should not be mixed in aluminum, tin, or zinc containers. 2. Solutions are effective in most concentrations, but normally the more concentrated the solution the faster the decontamination.

Ethylene oxide gas is generally not a satisfactory decontaminant for the interior of buildings because of the danger from explosion. Ethylene oxide is recommended for the decontamination of equipment where suitable gasproof shelters can be improvised outdoors.

Relatively large quantities of carboxide are required for decontamination. An absolutely gastight enclosure is required for carboxide as contrasted with a reasonably gastight chamber required for ethylene oxide.

Bleach is very corrosive and therefore harmful to metals, but bleach and lye are recommended for exterior surfaces. Details regarding the use of these materials are given in the following paragraphs and summarized in Table 4.

D1.04 Suppressants

Where it is impossible or impracticable to decontaminate large outdoor areas, the danger from infection can be reduced by spraying such areas with dust suppressants, such as water, oil, tar, and asphalt. Although these materials will not kill pathogens, they will reduce the dispersion of the organisms by sealing them to the surface. In some cases, this procedure may actually eliminate the necessity for decontamination other than that effected by natural weathering. (See D3.12.)

D1.05 Sterilization and Disinfection

1. Sterilization. The term sterilization denotes complete destruction of all kinds of pathogens in any form. Spores, which are included in this category, are defined as inactive, resting, or resistant forms of plant or animal cells capable of enduring prolonged drought, extremes of heat or cold, or other adverse living conditions, and under proper conditions, of developing into a new individual.

2. Disinfection. Disinfection is the destruction or reduction of pathogens by an amount to permit reasonably safe handling of the article or material. This may mean partial destruction of all of one species and none of another, partial destruction of all species, or complete destruction of the vegetative form but only ineffectiveness as far as the spore form of any species is concerned. That is, disinfection may not be 100 percent effective, at least not within practical time limits.

3. Decontaminating Agents Considered. In general, only decontaminating agents that effect 100-percent sterilization will be discussed in the sections that follow. How-

ever, two disinfecting agents used in personnel decontamination--hexachlorophene soap and several alcohols--will be considered. While these are not true decontaminating agents from the standpoint of sterilization, they may be applied to the human body with fairly effective results. Certain disinfecting agents not considered here, either because they do not effect complete sterilization or for other practical considerations, are phenol, the cresols, hydrogen peroxide, potassium permanganate, bichloride of mercury, methyl bromide, triethylene glycol, and DANC solution. Many of the agents not discussed herein are effective on a particular pathogen or on only one of its forms.

Because it is probable that the Public Works Officer will not know what particular pathogens are to be destroyed, he should only employ an all-purpose decontaminant. (See Table 4.)

D1.06 Decontamination Squads

1. Organization and Training. Whenever possible, all decontamination should be done by specially trained decontamination squads provided with materials, equipment, and transportation necessary for the performance of their duties. Ordinarily these squads can and should be trained to perform decontamination of radiological and chemical as well as biological warfare agents, as is planned for damage control units on shipboard. It is estimated that a 16-man squad is generally the most desirable size. Because of the difficulty of working for long periods in masks and protective clothing, frequent rest periods will be necessary. Therefore it is considered advisable to divide the squad into two crews of approximately 8 men each so that one crew can rest while the other works. The squad leader is usually responsible for all work assigned to his squad, and normally he will lead one crew of the squad in their work. The assistant squad leader may be assigned to the second crew to lead them when the first crew is relieved. It is helpful to have the squad leader and assistant squad leader identified by an armband or other distinctive marking.

Because of their training, squad members, when not required for decontamination work, will be valuable in locating contaminated areas after an attack or in performing other duties that require more than a basic knowledge of biological defense.

2. Protective Clothing and Equipment. All men engaged in decontamination work should wear masks, impermeable hoods, or rubber coated gloves, and rubber boots. Clothing

need not be treated or made of any special protective material, but all parts of the body must be covered with at least two layers of cloth. Coveralls, long underwear, and socks may generally constitute a satisfactory outfit, but other articles of clothing may be added as required by the weather. After donning masks and clothing, each member of the squad must be inspected by the squad or crew leader to see that he is properly protected. Extra sets of clothing and protective equipment may be required for use by the decontamination squads.

D1.07 General Order of Decontamination

Decontamination operations should begin immediately after a biological attack to reduce the danger of secondary aerosol infection and to enable personnel to resume work as soon as possible. Persons should not be confined to shelters or required to wear gas masks any longer than is absolutely necessary for their protection.

Up to the present time, scientific methods of primary aerosol decontamination have been limited to confined spaces. The order in which the various buildings and areas are decontaminated depends upon their importance in re-establishing operations and whether or not personnel can work efficiently in such areas while wearing masks and other protective equipment.

Facilities with a high decontamination priority include command and communication centers, hospital and first-aid facilities, and areas where masking and sheltering is impracticable or impossible. Less essential areas that are temporarily evacuated would be decontaminated in turn.

D1.08 Simulant Agent Dispenser

A simulant agent dispenser is now under development which will be about the size of a 12-oz insect spray bomb. From a defense standpoint the primary use of the dispenser will be for training purposes, and as a means of testing the effectiveness of decontamination. Areas or equipment to be decontaminated will have small control areas exposed to the simulant agent spray and samples taken before and after decontamination. These samples will then give a reliable indication of the effectiveness of the decontamination process.

Section 2. INTERIOR DECONTAMINATION

D2.01 Formalin

The normal (Navy Stock) formalin is a solution of water, methanol, and 37 percent formaldehyde (HCHO). Formalin vapor is considered one of the best decontaminants for interiors. For effective decontamination, THE VAPOR SHOULD REMAIN IN CONTACT WITH THE INFECTED AREA FOR 16 HOURS. Because the bactericidal action of formalin improves with increased relative humidity, it is recommended that the stock solution be diluted with equal parts of water.

D2.02 Methods of Vaporizing

1. Steam. One method of vaporizing formalin is to boil it, using steam coils, or to bubble steam through an open container filled with the solution. A steam cleaning machine can be used for this purpose, with the steam-generating apparatus located outside the building (to prevent contact of the open flame with formalin gas) and connected with the formalin container by a hose. The steam generator should be adjusted to provide sufficient steam for the rapid vaporization of the liquid. However, the pressure must be low enough to prevent the liquid from being blown from the container.

2. High-Pressure Spray. Where the use of steam is not practical, the solution may be vaporized by means of a high-pressure (50 psi) spray device, such as ordinary paint spray equipment.

D2.03 Preparation of Buildings

The building to be decontaminated does not need to be sealed tight to prevent vapor loss, but windows and doors must be closed and large openings shut off from the outside. Normal cracks, such as those around windows and doors, need not be sealed. However, if only a portion of a building is to be decontaminated, it should be sealed off from the rest of the building.

Drawers of desks, benches, and files should remain open during the decontaminating process. Because formalin vapor will not penetrate into tiny crevices that may be contaminated, closed books or tightly packed papers can not be decontaminated on their shielded surfaces. They should be decontaminated by the method prescribed for equipment, as described in D5.02 or D5.06.

D2.04 Formalin Requirements for Sterilization

When properly dispersed, one-thirtieth of an ounce of formalin, full strength, will sterilize one cubic foot of space within a building; about one quart is required for a thousand cubic feet. A building of 400,000 cubic feet (200' x 100' x 20') will require 100 gallons of formalin.

The formalin working solution should be 50 percent water and 50 percent formalin. To decontaminate spaces above 70° F, 2 quarts of the working solution per 1,000 cubic feet are required. As the temperature decreases, the amount of the formalin solution must be increased, that is, one gallon (working solution) per 1,000 cubic feet must be used between 60° F and 70° F, whereas two gallons must be used for the same space in temperatures between 40° F and 60° F. Decontamination at temperatures below 40° F is not effective. Resort must be made to space heating in such a case.

D2.05 Effects of Formalin Decontamination

1. Materials. Formalin will not generally damage materials or surfaces by corrosion. However, it is possible that the increased humidity and the presence of steam or vapor will be harmful to some delicate objects or mechanisms. Ordinary electric wiring and fabrics are not affected, but complex electronic devices might be damaged. Papers may curl in drying after exposure to formalin vapor.

2. Persons. Although formalin vapor is toxic to man, especially if it is inhaled, there is little probability of danger except to persons trapped in an enclosure that is being decontaminated. This could result in death. Rooms containing formalin vapor should not be entered except in an emergency, and then only by the decontamination squad men when fully masked. The ordinary military-type mask is usually suitable; however, oxygen breather masks should be provided for all persons who are likely to encounter an appreciable concentration of fumes. The vapor has an easily detected odor; and it causes some distress, such as upper respiratory irritation and tears, before producing any lasting damage.

D2.06 Precautions

If possible, formalin should be kept in completely enclosed equipment to protect workers from the effects of exposure to the vapor. When formalin must be used in open containers, forced draft hoods will be of great value. Spills may be neutralized with ammonia and then washed with water. Rubber or other waterproof gloves should be worn to protect

the hands from any form of formalin (liquid, vapor, or powdered formaldehyde). Exposure to formalin may cause the development of "formaldehyde rash," a contact dermatitis that manifests itself in a reddening of the skin, sometimes accompanied by blisters superimposed on the red areas. Lanolin or a similar protective agent may be helpful if rubbed on the skin of persons who are occasionally exposed to formalin.

D2.07 Cleanup Operations

After vaporization, the formaldehyde sterilizes by condensing with water upon all exposed surfaces. After sterilization has been accomplished, the formaldehyde evaporates as does the water. However, the water evaporates more rapidly than formaldehyde, leaving polymers behind. These polymers are toxic and water soluble, and continuously decompose giving off formaldehyde. Difficulty may be experienced in cleaning porous surfaces which have absorbed any quantity of the formaldehyde. The application of heat in conjunction with forced ventilation will usually render the space habitable within a reasonable length of time. Washing surfaces with hot water is the best method for removing the formaldehyde.

Section 3. EXTERIOR DECONTAMINATION

D3.01 General

The effect of corrosion caused by decontaminants is usually not as important on exterior surfaces as it is on equipment and on the interior of buildings; consequently the number of suitable decontaminating agents is greater for outside use. The two general classes of suitable agents are those that decontaminate (a) by the release of chlorine and (b) by their caustic action. Although there are many effective decontaminants in these two classifications, discussion herein will be limited to those materials that will probably be generally available to the Public Works Officer. These materials are solutions of calcium hypochlorite (HTH ordinarily used in water purification); chloride of lime (bleach, STB or Grade 3, used in chemical warfare decontamination); sodium hypochlorite (ordinary household bleach, such as Clorox, Dazzle, Purex, and others); and sodium hydroxide (caustic soda or lye).

D3.02 Concentration of Chlorine Compound Decontaminants

Any solution containing approximately 2 percent available chlorine and 1/2 of 1 percent of any anionic detergent, such as Nacconol, is effective on surfaces. Mixtures having more than 2 percent available chlorine may be diluted to give the desired concentration. Thin solutions are not suitable for vertical and inclined surfaces because they will run off before decontamination is complete. On such surfaces a thick slurry is required to increase the viscosity of the mixture so that it will adhere to the surface.

Bleach (STB or Grade 3) contains its own thickener, or slurry former. However, as in the case of sodium hypochlorite solutions--normally clear--it may be desirable to form a slurry by using some inert material. Lime or diatomaceous earth is recommended for this purpose.

D3.03 Spray Equipment

The mixes for horizontal surfaces may be applied with any spray equipment of suitable capacity. For large areas, the most suitable sprayer is the standard decontaminating apparatus, 400-gallon, M3A2 or M4 used for chemical warfare decontamination. For small areas, the standard chemical warfare 3-gallon M1 decontamination apparatus may be used. However, the current model of the M1 is not designed for use with highly corrosive materials; therefore, it must be

thoroughly cleaned immediately after use to prevent serious damage.

When slurry is sprayed on a vertical surface, a high-pressure device (400 psi) is required to pump the viscous material and to reach the top of high walls. The best equipment for this purpose is the standard 400-gallon decontaminating apparatus. This unit is designed to mix solutions (either slurry or thinner solutions) as well as to spray them on contaminated surfaces. Therefore, no auxiliary mixing equipment is required when this unit is used.

When the 3-gallon unit is used, however, the solutions must be mixed prior to filling the apparatus. Although mixing the bleach and water with a mechanical device is the most efficient method, hand mixing in a suitable container is practicable.

D3.04 Decontamination Operators

An operating crew of 4 men is required for the most efficient operation of the 400-gallon unit, while only one man (in addition to the mixing crew) is required for the 3-gallon unit. Because of the variables in the use of the 3-gallon unit, no estimate of cycle time of filling and spraying is possible. In the case of the 400-gallon apparatus, the time required for performing each of the various operations has been found to be as follows:

Operation	Minutes
Filling with water	10
Charging with bleach	20
Mixing	15
Spraying	20 (varies with rate of application)
Haul time (from water point to working area)	-- (varies with distance)

D3.05 Rate of Application of Chlorine Compounds

Table 5 contains the recommended mix and rate of application for the chlorine compounds that are generally available to the Public Works Officer. The mixture is sprayed at the rate indicated for the type of surface being decontaminated, and it is allowed to remain at least one hour to assure complete decontamination. To assure complete wetting of the surface, a suitable detergent should be added to all solutions, including the slurry, at the rate of 1/2 of 1 percent by weight. The effectiveness of the decontamination

on horizontal and vertical surfaces may be increased tremendously by a thorough scrubbing with either hand or power brooms.

D3.06 Selection of Decontaminant

All of the chlorine decontaminants are equally effective when used as recommended. Therefore, the choice will be governed by the availability of the material and the cost per unit of free chlorine. Bleach costs approximately 15 cents a pound, HTH costs 22 cents a pound, and sodium hypochlorite solution costs approximately 40 cents a gallon. Therefore, materials for one gallon of decontaminant having 2 percent available chlorine will cost approximately 8 cents when using bleach, 6 cents when using HTH, and 8 cents when using sodium hypochlorite.

D3.07 Concentration of Sodium Hydroxide

Sodium hydroxide solution (caustic soda or lye) is a highly effective decontaminant for flat surfaces. A 10-percent solution (by weight) of lye and water, when sprayed on a surface, will almost completely sterilize the area in one hour. On sloping surfaces it has the same limitations as the thin solution containing free chlorine in that it tends to run off before decontamination is complete.

D3.08 Application of Sodium Hydroxide

No specific rate of application of sodium hydroxide is recommended other than to thoroughly wet the surface to be decontaminated. However, for the purpose of estimating requirements, the rates recommended in Table 1 for chlorine solution may be used, that is, 1/8 gal per sq yd for smooth concrete and 1/2 gal per sq yd for compacted earth. Mechanical agitation, such as brooming, will greatly improve the efficiency and increase the coverage of the lye solutions.

D3.09 Precautions and Protective Equipment

1. Chlorine Solution. Because the decontamination process may dislodge germs from the contaminated surfaces, operating crews should be equipped with military-type gas masks and complete outfits of biological warfare clothing as described in paragraph 2 of D1.06. Items of chemical warfare protective clothing should be added or substituted, where necessary, to protect against the decontaminant itself. All persons handling decontaminants should be careful to avoid getting the solutions on the skin or in the eyes or on the gas mask canister. If

Table 5

CHLORINE COMPOUNDS USED AS BIOLOGICAL WARFARE DECONTAMINANTS

Decontaminant	Conventional Use	Approximate percent available chlorine as packaged	Recommended mix (parts decontaminant to parts water by weight)	Type of surface to be treated	Recommended rate of approximate gal/sq yd	Conventional packaging
Calcium hypochlorite (HTH)	Water purification	70	3/97	Horizontal concrete	1/8	Powder, Navy Stocks 6-oz cans
				Horizontal packed earth	1/2	5-lb cans, 100-lb drums
Chloride of lime (bleach STB or Grade 3)[1]	Chemical warfare decontamination	30	7/93	Horizontal concrete	1/8	Powder, Navy Stocks 50-lb drums
				Horizontal packed earth	1/2	
			40/60	Vertical concrete	1/8	
Sodium hypochlorite (commercially available as household bleach)	Bleaching	5-10	Reduce to 2% available chlorine	Horizontal concrete	1/8	Liquid, Navy Stocks 1-qt jars and 5-gal carboys. Commercially available in pint, quart, and gallon jars.

[1]Bleach that has been in storage for extended periods of time will lose some available chlorine. In this case the concentration of the mix must be increased proportionately.

Antiset (chemical warfare) should be added at the rate of 1/2 lb of antiset per 100 lb of bleach when using the slurry in the 400-gal decontaminating apparatus.

any of the solution should come in contact with the body, it should be immediately washed off with clear water.

Men handling and mixing decontaminants outside the contaminated area should be equipped with goggles, rubber gloves, boots, and slickers for their personal protection.

2. Sodium Hydroxide Solutions. Particular care should be exercised in handling lye because both the solid and liquid forms attack the skin, eyes, and clothing. Because of the heat that is liberated when solutions are prepared, the containers should not be handled with the bare hands. Lye does not give off a poisonous vapor, but it is poisonous if swallowed; therefore goggles, rubber suits, rubber gloves, and rubber boots should be used during all operations with this chemical. Spillage may be neutralized by weak acid such as citric or acetic acid (vinegar).

D3.10 Corrosion

All of these decontamination agents are highly corrosive to metals and will damage some plastics and fabrics. Where the decontaminants have contacted metal, the surfaces should be rinsed with water and then treated with oil or grease.

D3.11 Natural Decontamination

Land surfaces, streets, and sidewalks found to be contaminated with biological warfare agents can be ruled out-of-bounds to personnel and vehicles. This cessation of traffic will considerably reduce secondary infectious aerosols and the biological warfare agents will die by natural processes. However, it may not be possible to restrict some areas, and solar radiation and aeration may be sufficient to decontaminate the areas to a limited extent only. When contaminated surfaces and terrain must be used by traffic, the danger resulting from secondary aerosols will be reduced by the use of suppressants or by the laying down of tarpaper walkways.

D3.12 Use of Suppressants

1. Water. When water is used as a suppressant (see D1.04), it should be applied carefully and directly downward to prevent the formation of secondary aerosols; high-pressure spraying of water on surfaces is therefore not satisfactory. Any equipment available, such as tank trucks equipped with spray bars, a hose and nozzle attached to a water hydrant, or a sprinkling cart, can be used. Sufficient water should

be applied to thoroughly wet the surface of the terrain and vegetative growth. However, water does not kill pathogens; it merely seals them to the surface or washes them off. Because water is effective as a sealant only as long as the surface is wet, spraying must be repeated often. For this reason, also, it is not particularly efficient in climates where rapid drying may be expected.

2. Oil. Either fuel or lubricating oil used as a suppressant will prevent the formation of secondary aerosols for limited periods. The application should be sufficiently heavy to completely wet the surface and also leave some oil for subsequent penetration. Oil has a slightly more permanent effect than water, but even oil will eventually be drawn into the soil, leaving the surface dry.

Salvaged crankcase oil, Navy Special, Bunker C, or diesel fuel oils can be used with bituminous distributors or tank trucks equipped with spray bars for treating large areas; the M1 sprayer apparatus may be used for small areas. However, one effect of oil is that it will kill or retard vegetative growth for some time.

3. Asphalt and Tar. Asphalt and tar are the most effective suppressants. If applied hot, they may kill a large number, but not all, of the pathogens. However, a number of factors affect their use: topography, vegetation, porous character of the surface to be treated, and subsequent use of the area. The amount used to coat fine dust particles and to penetrate the surface sufficiently to provide a fairly good sealing of a loose surface will vary greatly according to its porosity and topography. If the first treatment does not provide sufficient protection, it may be necessary to delay 24 hours or longer to allow the material to "cure" before a subsequent covering may be applied. A light coating of asphalt will not kill or retard vegetative growth, but tar will.

A standard bituminous liquid distributor sprayer can be used for applying asphalt, and one gallon of MC-1 to one square yard will usually give sufficient coverage on a well-compacted surface.

Section 4. DECONTAMINATION OF PERSONNEL

D4.01 General

Personnel to be decontaminated may be classified into two groups: (a) "resident," comprising persons such as decontamination squad men who have been contaminated but must remain in the contaminated area until it is cleaned up; and (b) "evacuated," comprising persons to be evacuated temporarily or permanently. Duplicate undressing rooms, shower rooms, and other facilities must be provided for men and women. Permanent and temporary facilities and the procedures for decontaminating personnel in these groups are described in the following paragraphs.

D4.02 Permanent Facilities

Resident personnel will require a cleansing station similar in purpose to that illustrated in Figure 6. The facility should be located in or near an essential area that is considered likely to become contaminated. As far as feasible, the cleansing stations should be the same stations as are provided for chemical and radiological decontamination.

1. Capacity of Facility. The extent of the permanent cleansing facility is predicated upon two assumptions:

(1) That the facility will be located in or near an essential area likely to become contaminated.

(2) That such a facility will be provided only for resident personnel, it being economically unfeasible to provide more extensive facilities.

2. Use of Facility. Until such time as all the surrounding area is declared to be safe, resident personnel must be masked as they enter and leave the cleansing station. In regular operation, the waiting room provides only a place to rest, eat, drink, and perform other necessary functions otherwise impossible for persons wearing a mask and other protective gear. After the area has been decontaminated, the shelter may be employed to process unmasked personnel.

3. Storage of Gear. All of the decontamination squads' materials for detection, first aid, and decontamination purposes are to be stored in or near the cleansing station, except materials with corrosive or toxic properties. Thus, bleach and DANC must not be stored in the shelter.

Squad equipment that is not readily damaged by corrosion may be stored with these materials.

4. Basic Station Components. The basic components of a cleansing station are (a) outside unclean area for undressing; (b) washing area; and (c) clean area for drying and dressing. Other facilities may be added as required. These three components are briefly described below.

a. Outside Undressing Area. Where feasible, the unclean undressing areas should be located outside the cleansing station, near its entrance, as shown in Figure 6. However, use of such an outside facility is hazardous when mustard gas is present concurrently with biologicals; in such case, the inside facility must be used. The cleansing procedure described below is based upon the absence of an outside dressing area.

b. Washing Area. The floors of the washing area should be constructed with drains for rapid removal of the dirty water. Ultimate disposal of waste water is discussed in Section 7, "Decontamination of Water."

c. Clean Area. The clean area for drying and dressing is located near the exit to the washing area and convenient to facilities for storage and issue of clean clothing and protective gear, including masks. The latter must be ready for issue in case the area outside the shelter is still contaminated.

One part of the clean area may be set aside as a decontamination control center. Another may be used for storage of squad equipment (see paragraph 3 above). Facilities for sleeping and serving food to the decontamination squads may also be provided. Any of these subdivisions of the clean area may be partitioned off as desired.

5. Cleansing Procedure. The basic procedure to assure effective decontamination of personnel is outlined below.

(1) The man enters the air lock and removes all clothing except the mask. Clothing is placed in the contaminated clothing locker. A bench is provided in the air lock so that the feet may be swung from the dirty to the clean side.

(2) He then enters the second compartment of the air lock and finally gains entrance to the shower room.

(3) Here he applies 5-percent tincture of iodine to any cut or abrasion of the skin.

(4) He then proceeds immediately to the shower area. Each man soaps and rinses two or three times, using warm water and hexachlorophene soap; in the absence of this soap, any mild skin soap may be employed, reliance in such case being placed entirely upon mechanical action. In the absence of either, or as a useful adjunct, a complete rubdown with ethyl alcohol or isopropyl alcohol is recommended. Ethyl is applied as a 70-percent solution; higher or lower concentrations are less effective. Isopropyl is applied as an 80-percent solution. After showering, the mask is removed and placed in a covered GI can.

All parts, particularly the hair, must be treated with recommended soap or alcohols. Although neither is completely effective, both are very good and have no deleterious effect, as is produced by bleach or lye. Attendants in the washing area and all areas back to the entrance should be masked. From the washing area the men proceed to the clean area.

D4.03 <u>Temporary Facilities</u>

1. <u>General</u>. Evacuated personnel will utilize a cleansing station (Figure 7) similar to the improvised type recommended for use in <u>Chemical Warfare Defense</u> (TP-PL-3). This type of facility must be portable, mobile, or both, so that it can be readily oriented with the prevailing winds.

2. <u>Location</u>. The temporary facility should be located so that it will be relatively safe from contamination by direct attack or by aerosols (primary or secondary). A minimum isolation distance of two miles is recommended. Where there are prevailing winds, the facility should be upwind from the essential area. The station should be on a slight rise to facilitate gravity drainage of wash water.

3. <u>Washing and Clean Areas</u>. It is desirable to keep the washing and clean areas upwind from the unclean area. These areas should be at least 50 to 100 feet apart, as specified for chemical warfare defense, and more if practicable. Even 500 feet is not excessive provided this does not cause too much exposure of undressed personnel.

4. <u>Treatment of Waste Water</u>. Contaminated water should drain by gravity away from the washing area, and then it should be treated to destroy any pathogens it may carry. Regular treatment plants are discussed under Section 7, "Decontamination of Water."

In the event that no vesicants are mixed with the waste water, it may be channeled at one point into a single earth trench where bleach solution may be added to form a 200-ppm effluent. Subsequent dispersal on the surface of the ground is satisfactory.

If vesicants are known to be present, ponding within low earth dikes is recommended. Bleach in the dry state may be added to the ponded water.

5. Unclean Area. The unclean area should be roped or fenced off, and it may be roofed over to afford protection against the weather. However, the area should never be enclosed. A box or pile of moist mix (sand and bleach, 2 to 1) should be placed at the entrance to the area; all men must shuffle their feet in this mix as they enter. Benches are arranged to mark off the unclean ground area from the clean area.

6. Cleansing Procedure.

a. General. Evacuated personnel will be masked as they proceed to the temporary cleansing station. Transportation is desirable but not mandatory. Upon arrival, they will await cleansing at a point as far downwind from the facility as practicable and move up to the enclosed "unclean area" (see Figure 7) only as rapidly as accommodation and load permits. Such procedure is necessary to minimize the generation of secondary aerosols from the clothing of those contaminated. Otherwise, the calculated risk of exposure to those in the "washing area" is increased unnecessarily.

These precautions, and others explained in ensuing paragraphs, are aimed toward maintaining generally a clean, uncontaminated area from the washing area outward and upwind. Although some risk still remains, it is believed to have been reduced to practical limits in view of the large numbers of personnel possibly involved, the availability of funds, and the need to provide effective facilities within a reasonable time.

b. Cleansing Steps. Actual cleansing operations should be carried on as follows:

First, as the masked men sit on the benches, they remove their shoes on the unclean side, pivot on the bench, swing their feet to the clean side, and gently remove their outer clothing to avoid setting up a secondary aerosol of biological organisms. Contaminated clothing will be placed in GI cans or similar containers with tight covers.

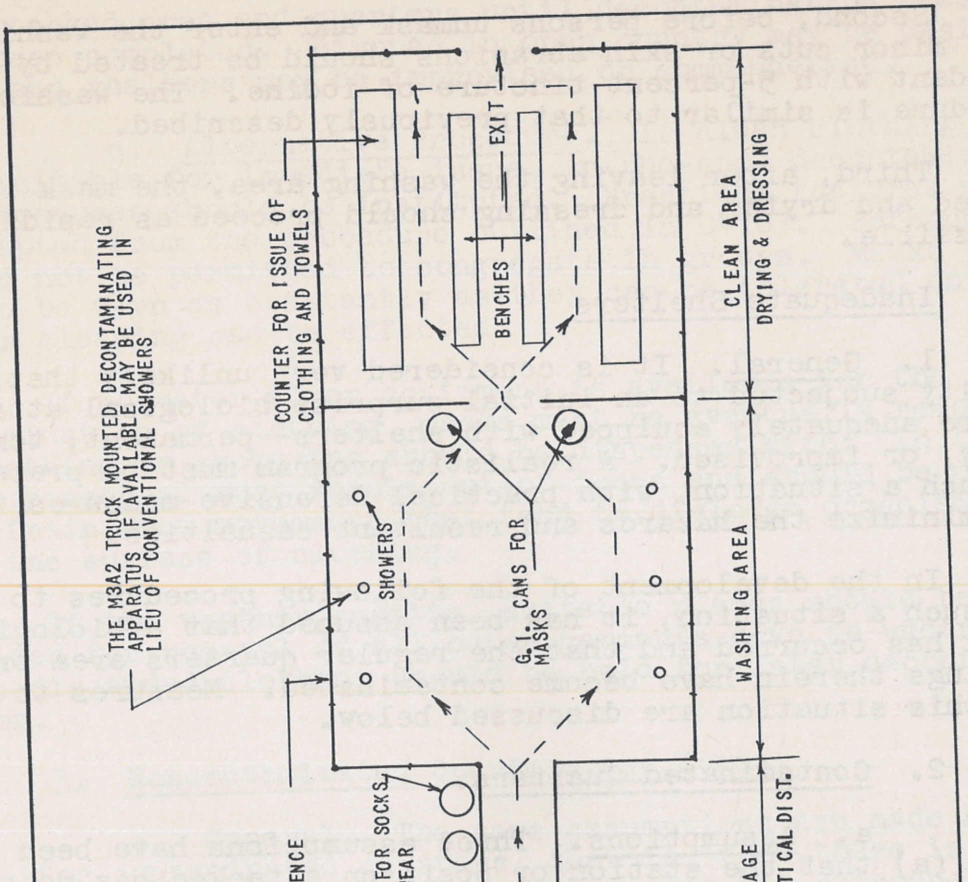


Figure 7
Suggested Layout of Improvised BW Cleansing Station

Second, before persons unmask and enter the washing area, minor cuts or skin abrasions should be treated by an attendant with 5-percent tincture of iodine. The washing procedure is similar to that previously described.

Third, after leaving the washing area, the mask is removed and drying and dressing should proceed as rapidly as possible.

D4.04 Inadequate Shelters

1. General. It is considered very unlikely that a facility subjected to an initial surprise biological attack will be adequately equipped with shelters--permanent, temporary, or improvised. A realistic program must be prepared for such a situation, with practical defensive measures that will minimize the hazards and resultant casualties.

In the development of the following procedures to meet such a situation, it has been assumed that a biological attack has occurred and that the regular quarters area or buildings therein have become contaminated. Measures to meet this situation are discussed below.

2. Contaminated Quarters.

a. Assumptions. Three assumptions have been made: (a) that the station or position attacked has no regular biological shelter or cleansing station; (b) that all personnel were masked at the time of attack; and (c) that all personnel not actively engaged in aggressive defensive tactics have taken refuge in the best shelters available. It may be further assumed that the surface of their clothing and gear has become only mildly contaminated.

b. Procedure. Cleansing steps should be as follows:

First, personnel under these conditions should be marched or transported to the nearest shower or bathing facilities, natural or otherwise, that are located in a noncontaminated and uninhabited area. Masks should be worn en route.

Second, if clean clothing is available for changing, procedure at washing area should be as outlined in paragraph 6 of D4.03, as closely as possible.

Third, decontaminated personnel must await return to

the attacked area and quarters until decontamination measures have been completed. Bivouac in open country may be desirable, and shelters may be improvised or commandeered.

c. Alternative Procedure. If clean clothing is not available for immediate issue, on-the-spot decontamination measures should be instituted. Practical features may be adapted from the procedure outlined in D4.03. Personnel should not be permitted to congregate in groups. Masks should be worn as constantly as they can be tolerated until proper cleaning can be effected.

If no material or equipment is available for the decontamination of clothing, masks must be eventually removed and bathing or showering should be dispensed with. In this case, personnel must remain out-of-doors and should be urged to refrain from movements that tend to dislodge organisms from the surface of clothing.

If the weather permits, suitable places should be provided for removal of all outer garments down to underwear; discarded clothing should be held for later decontamination.

3. Noncontaminated Quarters and Homes.

a. General. The same assumptions are made as those for contaminated quarters, that is, that there is no regular shelter or cleansing station, that all personnel were masked when attacked, and that all personnel not defensively employed have taken refuge in the best shelters at hand. In this case, however, it is assumed that quartering areas, barracks, or homes are clean. In that case, procedure should be the same as that for temporary shelter cleansing, as closely as possible.

As an example, personnel contaminated in the Washington, D. C., military office area, such as BuDocks building and vicinity, would mask themselves and travel by private car or bus to their homes. Only masked personnel would be allowed aboard designated buses.

b. Cleansing Procedure. Upon arrival at home or quarters, each person must remove all clothing, except underwear, outside the door. The mask will be discarded just prior to entering the building. Thereafter, the procedure set forth in paragraph 2 of D4.04 will be followed as closely as possible.

c. Care of Contaminated Clothing. Discarded clothing should be sprinkled with water to suppress biological organisms and then placed in a container containing a sterilizing solution. Any chlorine laundry bleach is suitable for this purpose; one part chlorine to 200 parts of water will be satisfactory. It is recommended that clothes be soaked for several hours.

Section 5. DECONTAMINATION OF EQUIPMENT

D5.01 Ethylene Oxide

Ethylene oxide (C_2H_4O) gas is one of the best decontaminants for equipment because it penetrates all remote recesses. It does not have a corrosive effect on metals and may be used with safety on delicate electronic equipment, books, papers, and fabrics, including clothing. However, because of its explosive nature, it should not be used indoors. Moisture is not required in the decontamination process, so the deleterious effects caused by excessive humidity are avoided.

Ethylene oxide in 3-pound metal cylinders, complete with valves, is available from commercial chemical sources.

D5.02 Procedure for Decontamination

1. Placement. The material to be decontaminated should be placed outside in the open air, surrounded by a shallow trench about a foot wide and a foot deep. When the ground is completely dry or only slightly moist, no special precautions are required. However, the decontaminating action of the gas is retarded if excessive moisture is present; therefore, if equipment is sterilized immediately after a rain or dew, a moistureproof ground sheet should be laid under the equipment.

2. Gasproof Tarpaulins. A gasproof tarpaulin is thrown over the equipment with the edges projecting approximately a foot beyond the outside edge of the trench. The trench is then backfilled and the earth compacted to form a satisfactory gas seal. Where hard surfaces preclude the digging of a trench, a corresponding amount of earth or sand may be placed on the projecting edges of the tarpaulin to form a gas seal. For automotive equipment, a tarpaulin approximately 30 feet by 30 feet would be required. (See Figure 8.) If a large tarpaulin is not available, equipment may be placed in a concrete or earth pit covered with a

smaller tarpaulin.

Until gasproof tarpaulins are developed and provided as a standard stock item, the Public Works Officer will have to improvise a cover, possibly by coating an ordinary tarpaulin with vinyl plastic. This plastic material was used in "moth-balling" operations on deactivated ships. Specification MIL-L-3921 describes a moistureproof, vaporproof, flexible barrier material, costing 24 cents a square yard, that may serve in place of a treated canvas tarpaulin. A vinyl-coated aluminum foil described in specification JAN-P-131 as Type I, Class A, is also suitable. This foil comes in rolls 38 inches wide and costs approximately 10 cents a square foot. Any size sheet can be formed from either of these two materials by sealing them with a hot iron.

3. Ethylene Oxide Cylinders. Place one (1) 3-pound cylinder of ethylene oxide underneath the tarpaulin for each 100 cu ft of volume enclosed. The cylinder should be placed on its side on a metal pan so that after the valve is opened the contents can spray out and evaporate from a relatively large surface. The discharging liquid ethylene oxide should not come in contact with any rubber or plastic items.

D5.03 Ethylene Oxide Requirements for Decontamination

Six pounds of ethylene oxide are required to decontaminate 2,000 cubic feet at temperatures above 70° F. For temperatures less than 70° F, additional ethylene oxide is required: 120 pounds at 60°, and 180 pounds at 50°. Decontamination at lower than 50° F is not effective. The gas is allowed to remain in contact with the contaminated equipment for at least 60 hours at a temperature of 75° F.

D5.04 Precautions with Ethylene Oxide

Because ethylene oxide is readily flammable and the gas is violently explosive between concentration ranges of 3 to 85 percent, it must be isolated from flame or spark. Furthermore, its use in decontamination must not be attempted indoors, except in controlled fumigation chambers.

Because the fumes of ethylene oxide are toxic, they should never be inhaled. The gas may be safely handled outside if moderate care is taken to avoid direct inhalation. Single inhalation tests of the vapor at concentrations of less than 250 parts per million show no symptoms. Some authorities have set 100 parts per million in air as the probable safe concentration limit for prolonged exposure to the vapor.

The first warning of the presence of ethylene oxide is a sweetish odor followed by irritation of the eyes and

Change 1
14 July 1953

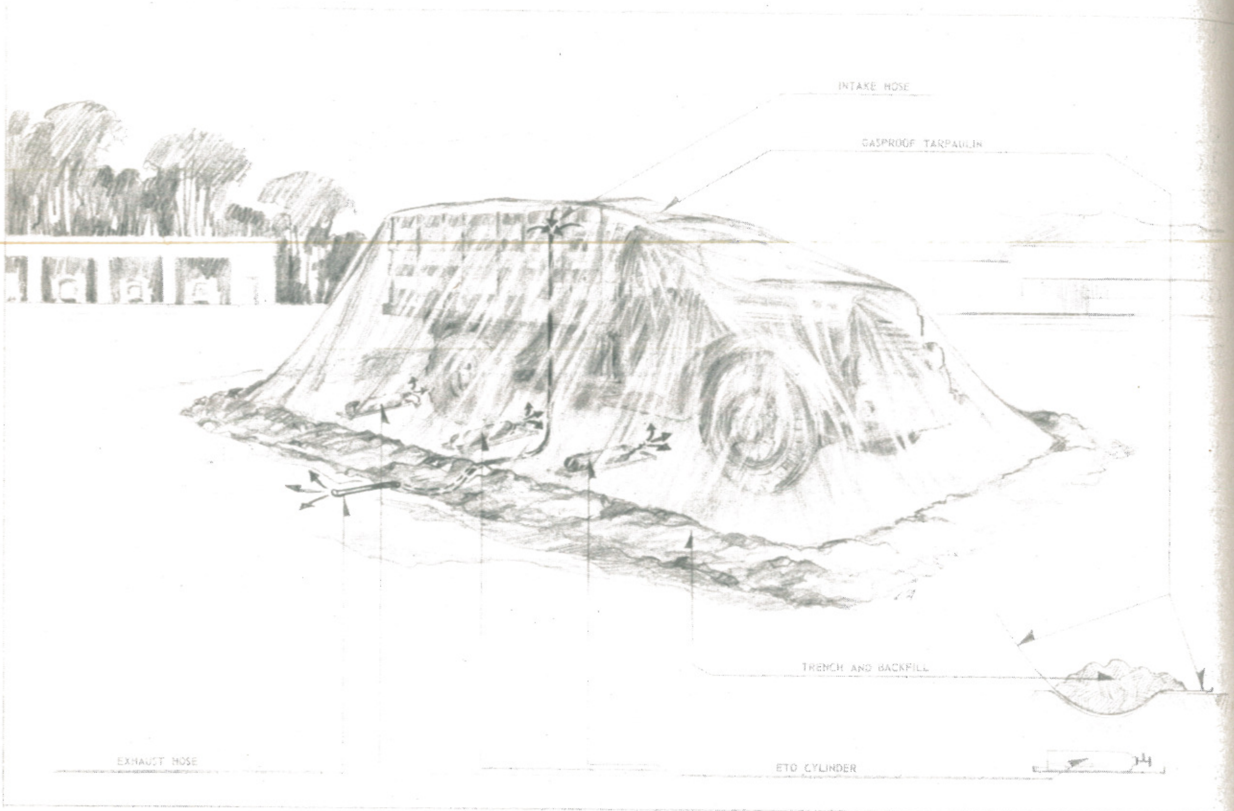


Figure 8
Suggested Arrangement for Decontamination of Equipment with ETO

nose. Fortunately, the irritation occurs at concentrations that are not injurious over short exposure. Single or repeated exposure to concentrations not causing other symptoms may result in nausea and vomiting. However, no cases have been reported of chronic poisoning caused by ethylene oxide.

If ethylene oxide liquid is spilled on the skin, it may be removed by blotting with a dry cloth. The skin must then be kept uncovered to permit complete evaporation. Clothing or shoes that have been wet with ethylene oxide must be removed immediately and completely dried and aerated before being reworn Instructions for the safe handling and use of ethylene oxide are set forth in appendix A.

D5.05 Carboxide

Carboxide, a mixture of 10 percent ethylene oxide and 90 percent carbon dioxide, is nonexplosive; therefore, it may be used safely inside of buildings.

As a decontaminant, carboxide is used in much the same way as ethylene oxide, except that four times the contact time (24 hours) and double the amount per unit volume is required. (See D5.03.)

D5.06 Procedure for Decontamination

1. Selection of Chamber. An absolutely gasproof space is required for decontamination with carboxide. A suitable chamber may be improvised in any permanent or temporary building; it must be reasonably tight and have doors large enough to permit the entry of the equipment to be decontaminated.

The chamber selected for gasproofing should not have air ducts, power panels, roof ventilators, or utility control valves that affect other parts of the building. To conserve the carboxide gas, the proposed chamber should be as small as possible, consistent with the amount and the size of the equipment to be decontaminated.

2. Preparation of Chamber.

a. Sealing Cracks. The chamber selected for decontamination purposes should be examined to detect the source of possible gas leaks. Cracks larger than 1/8 of an inch wide must be sealed with a calking compound or with adhesive tape. (See Tape, adhesive, treated cloth type 1, color light gray, 2 1/2 inches wide, General Stores Stock No. 53-T-1084-665.) Vents, floor drains, and other large openings can be fitted with wood, canvas, or metal coverings

before spraying.

b. Gasproofing. Gasproofing the chamber may be done by spraying the interior, including the walls and all the doors except the entrance door, with a strippable plastic film. Concrete floors, however, need not be sprayed. (See Strippable plastic coating, spray type, General Stores Stock No. 52-C-2250.)

An ordinary paint spray apparatus equipped with a nozzle that will spray a 6- to 8-inch band at 12 inches should be used. The coating should be applied as heavily as possible without excessive running. An average thickness of .01 inch can be applied in one pass, and spraying should be repeated until approximately a .04-inch film has been built up. Approximately 16 gallons per 100 square feet will be necessary to obtain the film required, and this will dry in 16 hours at 70° F. As an extra precaution, an additional coating may be sprayed over the cracks.

c. Piping. It will be necessary to provide a one-inch pipe inlet fitted with adapter for connecting to cylinder; it should be located near the floor, for the introduction of the gas. A 2-inch outlet pipe should be installed close to the highest point of the chamber, to release the air as the carboxide gas enters the chamber. The outlet pipe should be threaded for an ordinary pipe cap and located in a convenient place for removing and installing the cap.

d. Sealing Entrance Door. When the interior of the chamber is dry, the decontamination process may be started. After the equipment has been arranged within the enclosure, the entrance door is closed and sealed on the outside with tape, over which a coating of film is sprayed. When the equipment is ready to be removed, the plastic material is stripped from the exterior door only. This sealing process is repeated as required to decontaminate all equipment.

D5.07 Precautions with Carboxide

Although carboxide is nonexplosive, the same general precautions must be observed in decontaminating with this chemical as with ethylene oxide.

However, the vapors of the plastic spray are flammable and they will ignite during spraying and drying in the presence of an open flame or spark.

The gas inlet should be at least 5 feet from any metal surface, and a clear area at least 3 ft square around the inlet should be provided.

Section 6. DECONTAMINATION OF PERSONAL EQUIPMENT

D6.01 General

Clothing and other personal equipment may be decontaminated by the use of mixtures such as carboxide or ethylene oxide, also by laundering and boiling. Although no method will be suitable for all conditions, it is considered that at least one of the methods described below will be practical for any activity. When a gasproof chamber is available (see D5.06), the procedure outlined for decontamination of equipment is likely to be the most desirable because it requires minimum labor and material.

D6.02 Use of Ethylene Oxide and Carboxide

1. Large-Scale Procedure. Decontamination of clothing requires the same facilities, equipment, time, and precautions that are necessary in decontaminating other forms of equipment. When the recommended equipment is available, the clothing is arranged loosely on the floor or shelves in piles consisting of one complete outfit per pile.

After decontamination, clothing must be aerated by spreading or hanging it in the open air for a minimum of 15 minutes. However, rubber and leather items will require as much as several hours for adequate aeration, and they should be arranged to permit air currents to reach all surfaces. Aeration is required as long as the odor of gas can be detected.

2. Expedient Procedure.

a. General. When a gasproof chamber is not available, limited quantities of clothing may be decontaminated by the use of ethylene oxide ampules in a vaporproof bag. It is recommended that the empty bags be tacked to two wooden frames, the width of the sack apart, to facilitate handling and minimize the risk of contaminating the exterior of the bags.

b. Vaporproof Bag. Any vaporproof bag that can be tightly sealed may be used for this procedure. A suitable bag is the gas-resistant sack used to transport clothing contaminated by chemical warfare agents. Another suitable type is the delousing bag designed to fumigate clothing.

The Department of the Army has under development a water-

proof clothing bag that will be procured for issue in the near future.

c. Decontaminant. It is planned to procure ethylene oxide in glass ampules, with cloth covering, designed to be broken inside the sealed gasproof bag. These ampules will be approximately 1 inch in diameter and 5 1/2 inches long. Each will hold 25 milliliters of liquid ethylene oxide.

d. Procedure. The following steps are recommended:

First, bags should be filled loosely with clothing and the required number of ampules inserted, two ampules for each complete outfit; when more than one is required, the ampules should be spaced to give maximum dispersion of ethylene oxide. The location of each ampule should be noted.

Second, after the bag is sealed, the ampules are broken with a blunt object (such as the heel of a shoe), care being taken to avoid ripping the bag. When all of the ampules have been broken, the bag should be rolled around on the ground or floor for five minutes to assure dispersion of the gas throughout the clothing.

Third, the filled bags should be stored at a minimum temperature of 70° F for 12 to 16 hours. The clothing is then ready to be aerated, as previously described.

e. Precautions. Personnel handling contaminated clothing should be provided with the protective equipment recommended for decontamination squads. Because of the explosive and toxic characteristics of ethylene oxide, the following precautions also should be observed:

(1) Use ethylene oxide ampules only in a well-ventilated building or in the open.

(2) Do not decontaminate in a building where there may be open flames, hot wires, or sparks.

(3) Open the bags very cautiously, and avoid breathing the vapor. Remove clothing from bags quickly.

D6.03 Hypochlorite-Laundering Method

1. General. Probably the most generally applicable method of decontamination is a combination of chlorine soaking followed by ordinary laundering. As previously outlined, the contaminated clothing should have been deposited in GI cans at

the personnel decontamination center, where it should have been soaking for several hours in a 2,000 ppm chlorine and 1/2 of 1 percent suitable anionic detergent solution. If necessary, more solution is added to completely cover the clothing; the cans are then thoroughly washed on the outside with a stronger bleach solution (see paragraph 2 below) to prevent later contamination of laundry. The cans should then be removed to the clothing decontamination station for processing, as described below. Certain precautions required are outlined in paragraph 5 below.

2. Soaking Solution. For soaking at the clothing decontamination station, a solution of bleach should be prepared, consisting of 1 part bleach (STB or Grade 3) to 99 parts of water by weight. Any other chlorine compound (see Section 3) may be substituted for bleach, provided it makes a solution of 0.2% (2,000 ppm) of available chlorine. Detergent should be added to all solutions (1/2 of 1 percent) to assure complete wetting of the material being decontaminated. Although the size and shape of the container will affect the quantity of solution, approximately two gallons will be required per pound of clothing.

If available, the 400-gallon M4 or M3A2 decontaminating apparatus, a chemical warfare defense item, should be used for preparation of the solution. In an emergency the solution can be mixed by hand; GI cans can be used.

3. Soaking Process. It is desirable to combine the soaking process with the normal laundering operation, which only requires ordinary laundry equipment. While not necessary for the laundry process, the addition of 1 percent chlorine in the laundry water will obviate the necessity for further decontamination of the waste water.

The most satisfactory method for decontamination of masks is that outlined for clothing in D6.02 using ethylene oxide. This method is suitable for canisters as well as masks. Care must be taken, however, to blow the ethylene oxide from them prior to use.

4. Decontamination of Masks. The chlorine solution method, with some variations, is applicable for emergency decontamination of masks. The recommended procedure for the two types of masks is given below.

a. M9A1 Mask. The decontamination process should be as follows:

(1) Remove the canister (or waterproof with kit)

(2) Soak the mask for 5 minutes in the 2,000-ppm chlorine-detergent solution described above for clothing

(3) Remove from the solution and rinse thoroughly in clear water

(4) Shake off the excess water

(5) Hang upside down (head harness down) to dry

If necessary to reuse the canister of this mask, the rubber inlet plug and metal closure cap should be mounted on the canister, and the entire unit wiped with a rag dampened in the chlorine solution. If the inlet plug and metal closure cap have been lost, the outside of the canister must be wiped and wrapped in the wiping rag until ready for remounting on the mask.

b. <u>M3A1-10A1-6 Lightweight Service Mask</u>. Decontamination steps should be as follows:

(1) Remove the canister from the hose

(2) Soak the mask in chlorine-detergent solution

(3) Remove the mask from the solution and rinse thoroughly in clear water

(4) Shake excess water from the mask, taking care to remove water from the hose; for this purpose an air jet would be useful

(5) Hang upside down (head harness down) to dry

(6) After thorough drying, fit new canisters to the masks

5. Precautions.

a. Protective Equipment. The area where clothing is soaked with bleach solution must be treated as a contaminated area. The same protective equipment recommended for decontamination squads should be provided for the men who handle contaminated clothing.

b. Hypochlorite Solution. Hypochlorite solution is less damaging to the skin than are some other agents. However, users should avoid getting it on the skin or in the eyes; splashes on the skin should be removed immediately with clear water. Persons who work with or handle the solution **but are not** wearing full protective equipment should use goggles, rubber gloves, and rubber raincoats.

D6.04 Decontamination by Boiling

Some articles of clothing and personal equipment may be decontaminated by being boiled in water for 30 minutes, as described below.

1. Procedure. The contaminated articles are placed in any tank or container to which sufficient heat can be applied to raise the temperature of water to the boiling point. Approximately two gallons of container capacity will be required for each pound of clothing. In the absence of other facilities, GI cans and open wood fires may be used, but this method is slow.

Sufficient water should be added to completely cover the articles, and they should remain entirely immersed while being boiled, to assure complete sterilization.

2. Limitations. Although boiling is effective, it may damage some articles, as follows:

a. Woolens. Woolen fabrics may shrink excessively; to limit shrinkage, articles being boiled should not be stirred or agitated. While drying, shrinkage may be minimized by stretching the articles.

b. Leather and Plastics. Leather articles, and those containing plastic parts, may be seriously damaged by boiling.

c. Rubber. Masks and other rubber articles, such as gloves, may be boiled after canisters and plastic components have been removed.

Section 7. DECONTAMINATION OF WATER AND WASTE DISPOSAL

D7.01 Contaminating Agents

Water may be contaminated by pathogenic bacteria, fungi, viruses, rickettsiae, and protozoa, and also by their toxins.

D7.02 Decontamination Responsibility

The detection of contamination, the analysis of water samples, and the reporting of laboratory findings is primarily the responsibility of the Medical Officer; however, in all probability the Public Works Officer will have to assist in sampling. It should be cautioned that the ordinary methods of analysis, based on the presumptive presence of pathogens by coliform determination, will not suffice to effect complete protection.

D7.03 Decontamination Methods

The various water treatment methods covered, in the order in which equipment will probably be available, are:

(1) Procedures where regular water treatment facilities exist
(2) Procedures where regular water treatment facilities do not exist
(3) Decontamination of water in the field
(4) Chlor-dechlor process

In the event that there is a choice of methods, the order of selection should be as follows:

(1) Chlor-dechlor process
(2) Treatment with conventional equipment
(3) Treatment with improvised equipment
(4) Field treatment

D7.04 Physiological Effect of Chlorine

The high chlorine rates recommended for water decontamination will not affect the human body, but the water may have an unpleasant taste.

D7.05 Testing for Free Available Chlorine Residual

Most of the orthotolidine comparator outfits used in testing for free available chlorine residual are not calibrated beyond 2 ppm. If this is not adequate for all tests, the

sample may be diluted with distilled water, and the chlorine content indicated may be multiplied by the dilution factor to obtain the actual free available chlorine residual. That is, a sample diluted by an equal amount of distilled water and reading 2 ppm would be actually 4 ppm.

D7.06 Procedures for Treatment with Conventional Equipment

The problem of decontamination of pathogens, including toxins and special forms such as amoebic cysts, is not difficult where regular water treatment facilities exist and the chlorination process is used. However, more chlorine is required than for normal routine treatment.

1. Filtration by Rapid Sand Filters. Where filtration is accomplished by rapid sand filters, the following procedure is recommended:

(1) Prechlorinate to effect a free available residual of approximately 1 ppm after a suitable contact period; fifteen minutes or more is recommended if possible.

(2) Postchlorinate to effect a free available residual in the water, as it leaves the plant, of 5 ppm after 30 minutes, and of not less than 1 ppm in the water at the most distant point of the distribution system. If the 1 ppm is not obtained, then the 5 ppm at the plant discharge point must be sufficiently increased to raise the available residual, or chlorination booster stations must be installed in the distribution system.

(3) Normal rates of flow through rapid sand filters should be cut in half if feasible.

2. Filtration by Slow Sand Filters. Where slow sand filters are used, prechlorination may be employed to the fullest extent short of effecting a residual. This is necessary to protect the schmutzdecke coating of the sand particles from deterioration.

The process for postchlorination is the same as that for rapid sand filters, but the rates of flow through slow sand filters should remain unchanged. If the presence of **botulismus** toxin is suspected, the postchlorination contact period should be increased from 30 minutes to one hour. Treatment of toxins other than **botulismus** is not covered in this text. If other contamination is suspected, it is recommended that the Medical Officer be consulted.

D7.07 Procedures for Treatment with Improvised Equipment

Where a naval station obtains its water from a distant non-Navy source, contamination may occur en route that would require treatment at the point of use. If regular water treatment facilities do not exist, the following procedures are recommended:

(1) Boiling for 20 minutes
(2) Distillation, where such equipment is available
(3) Improvised chlorination (HTH solution or similar)
to effect a free available chlorine residual of 5 ppm after 30 minutes. This time should be increased to 1 hour if botulismus toxin is suspected.

Treated water should be preserved in a safe condition. Covered or closed storage containers should be used to protect the water from the ambient presence of any biological warfare aerosol.

D7.08 Procedure for Field Treatment

Decontamination of water in extremely small containers, such as canteens, may be effected by the use of iodine tablets presently issued and available for that purpose. The following procedure is recommended as the most efficacious against biological warfare agents:

(1) Add three tablets to each quart of water. (The one tablet specified in the directions on the bottle does not apply to all agents of biological warfare.)

(2) After 10 minutes, sniff to determine the iodine odor remaining.

(3) If a strong iodine odor is still present, allow 20 minutes more before drinking the water. If the odor of iodine is weak or has disappeared after 10 minutes, discard the water and start again with more than three tablets. A cut-and-try procedure must then be used to establish the proper number of tablets for decontaminating the water.

D7.09 Chlor-dechlor Process

1. Concentration. This process involves chlorination to a higher degree of free available residual than that required in other treatments. Chlorination to a free available residual of 10 ppm after a one-hour contact period is prescribed. After this period, a sufficient amount of a dechlorination agent to lower the residual to 0.4 ppm is

added to the water to effect palatability.

2. Effectiveness. The chlor-dechlor process is highly efficacious in destroying all pathogens, toxins, and protozoa. However, where regular plant facilities exist, it may be operationally difficult to hold a one-hour contact period. Unless there is a sufficient amount of clear-well storage in the plant, it will be impossible to hold all the water with 10 ppm residual for an hour and then introduce the dechlorinating agent. The dechlorinating agents employed--sulfur dioxide, sodium bisulfite, or sodium meta-bisulfite--are not usually as available as is chlorine or chlorine compound chemicals.

3. Treatment. Sulfur dioxide, a gas, is introduced into the water by a device called a sulfanator, which is similar to a vacuum solution feed chlorinator except for the metering component. It is best adapted to the dechlorination of large flows of water such as would be found in a regular treatment plant. In an emergency, a chlorinator could be used as a sulfanator.

Sodium bisulfite or sodium meta-bisulfite are introduced either by a dry feed solution device or directly, as in the case of the batch method employment. Solutions of these materials may also be fed with standard chlorinators.

Sodium thiosulfate may also be used for dechlorination; but because of its excessive cost, it is not recommended. However, most stations normally will have some on hand in the form of photographer's "hypo". The amount required may be established by a cut-and-try process, using orthotolidine solution to determine the desired residual.

The approximate theoretical amount of various agents required to dechlorinate 1 ppm of chlorine is as follows:

Agent	Amount
Sulfur dioxide, SO_2	1 ppm
Sodium bisulfite, $Na\,H\,SO_3$	2 ppm
Sodium meta-bisulfite, $Na_2\,S_2\,O_3$	1.3 ppm
Sodium thiosulfate $Na_2\,S_2\,O_3\,12H_2O$	7 ppm

D7.10 Precaution

Water that has been decontaminated by any of the recommended procedures must thereafter be guarded against further contamination.

D7.11 Waste Disposal

1. Sewage Disposal Facilities. Most sewage disposal plants that employ full treatment will achieve a great reduction of pathogens as the influent passes through the various processes. This reduction is accomplished through the removal of sedimentary solids as well as through adsorption and stabilization by oxidation processes. Natural destruction occasioned by unfavorable environment is a great factor, and chlorination is also very effective.

2. Treatment of Waste.

a. Normal Treatment. Usually the full treatment of sewage and other routine protective measures are sufficient to take care of normal pathogen loading. However, where such pathogen loading is abnormal, as might be the case after a biological attack, several additional precautions should be taken to protect plant employees and to render the final effluent at least no more hazardous than it would be under normal conditions.

b. Prechlorination. Prechlorination of the influent is recommended to the maximum degree short of interfering with the biochemical processes of the plant; this will be approximately 10 ppm, depending on the septicity of the influent. In case the outfall delivery time is long, it may be necessary to prechlorinate a considerable distance ahead of the plant inflow point. If this is done, septicity will be deterred and the chlorine demand reduced. Apart from the usual reasons for prechlorinating, such as controlling odor, it is essential in this instance to begin disinfection measures as early as possible in the over-all treatment process. This will provide a measure of protection for plant personnel.

c. Postchlorination. Additional chlorination must be employed just prior to the final discharge of the effluent from the treatment plant. This postchlorination may require as much as 20 ppm to 50 ppm to insure pathogen destruction. To obtain a satisfactory contact period, it may be advantageous to introduce the chlorine ahead of the secondary settling tanks.

d. Other Decontaminants. If chlorination equipment is not normally included as a part of the treatment plant, powdered HTH or bleach may be added to the water at a suitable point in the system.

e. Ultimate Disposal. The degree of effectiveness of postchlorination is an important factor in the ultimate

disposal of the effluent in eliminating not only normal hazards but other problems connected with the final disposition of the sewage effluent. Where there is broad irrigation or other methods involving quick drying, the generation of a windblown secondary aerosol is a distinct possibility. Where no secondary treatment is used, postchlorination assumes its greatest importance.

f. Solids. Pathogens contained in solids that are to be eventually reduced in the sludge digestion processes need not cause particular concern. It is considered that the time involved in treatment, together with extremely unfavorable environmental conditions, will accomplish significant destruction. These natural processes, together with routine sludge disposal practices, will probably eliminate any unusual hazards.

Section 8. DECONTAMINATION OF FOOD

D8.01 General

Considerable research is still required to determine the most effective methods of food decontamination. The information included in this section, therefore, is given only as a guide. The Medical Officer's advice and instructions should be solicited prior to the decontamination or consumption of food that is suspected to be contaminated by biological warfare agents. In general, contaminated food should be destroyed, but this decision should be made by the Medical Officer.

D8.02 Food in Cans and Bottles

Food in cans and bottles will be reasonably safe from biological attack other than that occasioned by sabotage. However, there is the danger of food becoming contaminated when it is taken from the container; the container itself, therefore, must be decontaminated before the food is removed. This may be accomplished by soaking bottles and cans in a solution of 2 percent available chlorine and 1/2 of 1 percent anionic detergent for 30 minutes.

D8.03 Food in Bulk

Bulk food items may be decontaminated by one of the following processes. Inasmuch as heat penetration varies with type and size of container and kind of food products processed, the times given are only average. Care should be exercised to assure complete penetration of heat throughout food for the period of time indicated.

(1) Cooking in a low-pressure cooker (5 pounds per square inch) at a temperature of 228° F for one hour.

(2) Cooking in an oven at a temperature of 250° to 300° F for 40 minutes.

(3) Boiling in water for 20 minutes.

(4) Boiling for 15 minutes liquids or foods that will melt under heat, such as butter. To prevent scorching, it may be necessary to heat this type of material over boiling water, using equipment similar to a double boiler.

Foods that will not withstand any of the above treatments, such as ice cream, must be destroyed.

D8.04 Packaged Foods

To prevent further contamination, cardboard and other packages that will not withstand soaking should be thoroughly wiped with a cloth moistened in a chlorine and detergent solution; the containers should then be allowed to dry for 30 minutes before they are opened. After the food has been removed from these packages, it should be decontaminated as prescribed for bulk items.

PART E. MATERIALS, EQUIPMENT, DEFENSE BILL, AND TRAINING

Section 1. MATERIALS AND EQUIPMENT

E1.01 Defense Materiel

Special allowance lists, the general nature of which is shown in Table 7, are being established for atomic biological, and chemical warfare defense materials and equipment. The actual procurement of materiel will be accomplished and the items will be distributed, as soon as they become available, by the Bureau having procurement and distribution responsibility for a specific item.

Table 6 contains a list of items that may be required for defense purposes and that are normally carried in station stock. These items are not included in Table 7. The procurement of any items shown in Table 6 for use specifically or mainly for ABC warfare defense is not presently intended or authorized.

E1.02 Estimating Requirements

1. Basis for Making Estimates. There have been insufficient large-scale field tests and no actual experience in biological warfare to serve as a basis for estimating biological warfare requirements. Consequently, it is difficult to develop a completely satisfactory basis for estimating requirements for decontaminating equipment and materials, exclusive of personal items such as masks. If allowances are based on personnel figures, a receiving station may be allotted a great deal more material than an air station, even though the latter may comprise an area many times greater. On the other hand, it may be necessary to decontaminate a larger percentage of the total area of the receiving station than of the air station. Estimating allowances on an area basis is equally unsatisfactory. A more satisfactory method would be to consider both area and personnel.

Until a definite basis for estimating requirements is developed, the following method is presented for consideration and modification, as necessary, to meet the specific needs of a command.

2. Proposed Method. The first step in the proposed method is to establish a station factor. This may be done by using the formula

$$F = \frac{1}{50} A \text{ plus } \frac{1}{10,000} P$$

where A = functional area of the station in acres, including buildings, walks, roadways, ramps, airstrips, parking lots, and an additional 300-foot safety zone

P = number of personnel on board

F = station factor. This factor, multiplied by a coefficient "C" for any item, as shown below, will indicate the minimum station requirements for that item. (See Tables 6 and 7.)

Example: Station A: 200 acres, of which 25% (50 acres) is functional; 1,000 personnel

Station factor $F = \frac{1}{50} \times 50 \text{ plus } \frac{1}{10,000} \times 1,000 = 1.1$

Station B: 600 acres, of which 50% (300 acres) is functional; 50,000 personnel

Station factor F = $\frac{1}{50}$ x 300 plus $\frac{1}{10,000}$ x 50,000 = 11.0

The coefficient "C" for formalin is 320 gallons. Station A, therefore, would require 1.1 x 320, or 352 gallons as a minimum stock. Station B would require 11.0 x 320, or 3,520 gallons as a minimum stock.

Section 2. BIOLOGICAL DEFENSE BILL AND TRAINING

E2.01 Defense Bill, Public Works Office Annex

1. Responsibility of the Public Works Officer. The biological annex to the station disaster plan, when promulgated, will indicate the chain of command and the mission of the Public Works Officer. On the basis of this directive, the Public Works Officer will develop his organization to accomplish his mission. It may be necessary for him to prepare and publish a supplemental bill outlining all of the details for his specific operation.

2. Suggested Bill. The speed with which sampling, decontamination, and evacuation are started after an attack may determine the effectiveness of the defense operations. Because of the wide variations from station to station, it is not possible in this publication to present a uniform, detailed bill for this purpose. However, to assure the initiation of that work with a minimum of delay, every man on a station must have some definite guide and a thorough knowledge of the plan of operations. A detailed bill is one method of disseminating such information. A complete Public Works Office Annex will include the following items in its bill:

(1) The names of men comprising the various crews, that is, decontamination, sampling, transportation, evacuation, and any others required. Some Public Works Officers may find it desirable to have special crews for decontaminating building interiors, equipment, outside terrain, and possibly personnel, if so directed by higher echelon.

(2) The location to which each crew will report in the event of attack.

(3) A delineation of the operating area for each crew. This is for planning purposes and is to serve as a guide until the situation can be evaluated. Competent author-

ity may redefine those areas as required.

(4) The location of materials and equipment required for each of the crews.

Because of the turnover in station personnel, it may be necessary to periodically revise the initial bill to reflect those changes. Changes may also be required to correct deficiencies in operation that are indicated by training exercises and practice alerts.

E2.02 Training

1. Relation to Chemical Warfare Defense Training. Biological warfare being a comparatively new field in comparison with chemical warfare, available data is not sufficient to establish any comprehensive program of training in defense measures. Many of the chemical warfare defense measures are applicable, however, and training should be combined with that needed for chemical and radiological defense whenever possible. Casualties could be reduced by planning personnel shelters and other defensive measures prior to an attack; by the wearing of masks and observing shelter discipline at the time of attack; and by an a dequate decontamination of personnel and equipment after an attack. Training and psychologically preparing persons before an attack will correct exaggerated ideas of the power of biological warfare and thereby prevent adverse effects on morale.

2. Courses and Publications. At the present time, no special biological defense training courses are available. A general introduction to biological warfare defense, however, is included in the radiological defense courses held at the Chemical Corps School, Fort McClellan, Alabama, and at the United States Damage Control and Training Center, Treasure Island, California. The current issue of BUPERS 15795, List of Naval Schools and Courses, contains the latest information regarding convening dates of these courses.

The Department of the Army is preparing a training circular, Defense Against Biological Attack, that will contain an outline for individual training. This course may be adapted for use by individual stations.

The Bureau of Naval Personnel has published a training manual that is entitled Chemical and Biological Warfare Defense, NavPers 10098.

The Public Works Officer and his staff should familiarize themselves with the pertinent information contained in this and other publications of the military services to implement an adequate training program.

3. Adequacy of Training Program. To assure a well-trained organization, the effectiveness of training should be studied regularly. Practice alerts, in whole or in part of the over-all biological warfare defense bill, will help to indicate the adequacy of the training program.

Table 6

ITEMS USEFUL IN BIOLOGICAL WARFARE DEFENSE AND NORMALLY IN STATION STOCKS

Item	Coef "C" for Station Factor of 1 (See Par. E1.02)	Unit Measure	Y&D or General Stores Stock No.	Use	Remarks
1. Calcium hypochlorite (HTH)	Requirements will depend on amount of bleach available--see Table 5 C=100 lb (for water treatment only)	lb	Y&D 51-C-454-10	Source of chlorine, when put into solution for BW decontamination	Generally used for water treatment. Special water treatment stock not required when other sources of chlorine are available. See paragraph D3.01.
2. Sodium hypochlorite solution; one form is ordinary household bleach	See HTH	gal	G 51-S-3299-50	Household bleach or 5.2% solution of sodium hypochlorite diluted to 2% strength as decontaminant	Sold in ships, stores, and used extensively in laundries. See paragraph D3.01.
3. Sodium thiosulfate	*C = 30 lb	lb	G 51-S-4318	Water treatment; dechlorination after treatment	Normally used in photographic process. See paragraph D7.09.
4. Caustic soda (lye)	See item HTH	lb	G 51-S-2000	In solution as decontaminant	Used generally in various washing processes. See paragraph D3.01.
5. Oil (Bunker)	As available	gal	GS 7-0-163	A suppressant for exterior surfaces	Paragraph D3.12.
6. Asphalt MC-1	As available	gal	G 59-A-182	A suppressant for exterior surfaces	Generally used as primer in asphalt paving. See paragraph D3.12.
7. Paint spray outfit	*C = 3 each	each	C40-S-65155-000	To vaporize formalin for interior decontamination, and apply strippable plastic film to seal gasproof chambers	Used ordinarily for applying paint on the station. See paragraph D2.02.
8. Laundry	Station laundry is satisfactory	each	Part of station facilities	Clothing decontamination	See paragraph D6.03.
9. Bituminous liquid distributor sprayer	As available	each	Y&D C-76-S-68774	Spraying suppressants	See paragraph D3.12.
10. Trucks, various sizes	As available	each	See remarks	Hauling decontamination materials, equipment, and personnel	Sizes and types will depend on equipment available and type of station.
11. Water tanks, trailer mounted	As available	each	Y&D C78-T-36730-000	Hauling water to portable showers and potable water to various parts of station	

Table 6

ITEMS USEFUL IN BIOLOGICAL WARFARE DEFENSE AND NORMALLY IN STATION STOCKS (Continued)

Item	Coef "C" for Station Factor of 1 (See Par. E1.02)	Unit Measure	Y&D or General Stores Stock No.	Use	Remarks
12. Street Sweepers	*C = 1/4	each	Y&D C76-S-87190-000	Mechanical agitation of chlorine solutions on exterior surfaces	See paragraph D3.05
13. Calking compound	*C = 50	lb	G52-C-3089-70	To seal cracks in shelters and gasproof chambers	See paragraph C3.07
14. Calking gun	*C = 3	each	Y&D 41-G-1306	To apply above compound	
15. Brush, scrub, with handles	*C = 50	each	G 38-B-3610	For mechanical agitation of chlorine compounds on exterior surfaces	See paragraph D3.05
16. G.I. Cans (32-gal)	*C = 50	each	G 42-C-1750	Soaking clothes during decontamination and mixing various decontaminants; also for handling discarded contaminated clothing	See paragraph D6.03
17. Signs (BW Contamination)	*C = 50	each	None	Marking contaminated areas	To be made on station. See paragraph B2.05.
18. Respirator, paint spray	*C = 50	each	Specification MIL-R-11148	Handling and mixing bleach when this is done outside contaminated area; gas mask is suitable replacement	
19. Goggles	*C = 50	pr	G 37-G-3450	Protection of personnel handling and mixing bleach, lye, and other caustic materials outside contaminated area	

*Those items that are strictly a function of personnel are recommended on a basis of quantity per 1,000 men. Other items are given as a function of station factor.

Table 7

ITEMS RECOMMENDED FOR BIOLOGICAL WARFARE DEFENSE

Item	* Suggested Requirements	Unit	Stock Number	Use	Remarks
Bleach (agent decontaminating) (STB)	C = 8,000	lb	C51-B-639-750	Exterior decontamination	
Formalin	C = 320	gal	G 52-F-860	Interior decontamination as vapor	See paragraph D2.01.
Ethylene oxide (ETO) gas cylinders	C = 225	lb		Decontamination of equipment. Gasproof tarpaulin or other suitable material required in conjunction with the gas	See paragraph D5.01.
Ethylene oxide ampules 25 ml	2,000 for 1,000 men	each	Y51-E-508-40	Decontamination of clothing. Gasproof bag required in conjunction with the ampules	See paragraph D6.02.
Nacconol detergent	C = 300	lb	G 51-D-107-30	Wetting agent, decontamination of personnel equipment	See paragraphs D3.02 and D6.03.
Sulphur dioxide gas	C = 30	lb	G 51-G-243-100	Dechlorination after superchlorination in water treatment	See paragraph D7.09.
Sodium bisulfite and/or Sodium meta bisulfite	C = 15	lb	Y51-S-2555-8000	Dechlorination of water after decontamination	For large batch treatment. See paragraph D7.09.
Carboxide, gas cylinders	C = 110	lb	G 51-G-136-20 G 51-G-136-25	Decontamination of equipment inside. Gasproof chamber required in conjunction with the gas	See paragraph D5.05.
Soap, hexachlorophene	100 bars per 1,000 men	bars	Y51-S-1605	Personnel decontamination--showers	See paragraph D4.02, cleaning procedure.
Isopropyl alcohol	30 gal per 1,000 men	gal	BUMED 1-243-540 or BUAER R51-F-516 BUAER R51-F-519 Y51-I-374-50	Personnel decontamination--washing	See paragraph D4.02, cleaning procedure.
Antiset M1, 6½-lb container	C = 6.2	each	C51-D-69-520	Mix with bleach (STB) when a slurry is desired	
Water tablets, iodine	1,050 bottles per 1,000 men	bottle	G51-T-4278	For treatment of small quantities of water, such as water in canteens	See paragraph D7.08.
Gasproof tarpaulins 30' x 30'	C = 1.2	each	See remarks	Used to improvise a chamber for decontamination of equipment with ETO	See paragraph D5.02. No stock item currently available.
Gasproof bag E13	1,050 per 1,000 men	each	Y27-B-122-123	Used to hold clothing and ETO for decontamination	

Table 7

ITEMS RECOMMENDED FOR BIOLOGICAL WARFARE DEFENSE (Continued)

Item	* Suggested Requirements	Unit	Stock Number	Use	Remarks
Strippable plastic coating	C = 145	gal	G 52-C-2250-10	Used to seal room for decontamination chamber or personnel shelter	See paragraph D5.06.
Tape, adhesive, treated, cloth type I, color light gray, 2½" wide	C = 12	roll	G 53-T-1084-665	To seal cracks prior to use of strippable plastic in preparation of decontamination chamber	See paragraph D5.06.
Vapor producer 15 gal/hr	C = .5	each	See remarks	To vaporize formalin	This item not stocked. Specification MIL-A-898A describes a suitable unit. See paragraph D2.02.
Hoods	250 per 1,000 men	each	C-37-H-1773 C-37-H-1774	For use w/gas masks, to prevent leakage around facepiece; will be required by all decontamination personnel	See paragraph C2.02.
Gloves, rubber	225 pr per 1,000 men	pr	G 37-G-2593	Decontamination squads	See paragraph C2.03.
Coveralls	250 pr per 1,000 men	each	Not available	Decontamination squads	To be modified with additions of double sleeves and legs from elbow and knee. See paragraph C2.03.
Drawers, long, ankle length	250 suits per 1,000 men	pr	55-D-545 to 55-D-555	Decontamination squads	See paragraph C2.03.
Undershirts, medium weight	250 suits per 1,000 men	each	55-U-389-5 to 55-U-414	Decontamination squads	See paragraph C2.03.
Repair kit, gas mask, LWS, or Repair kit, protective mask M9A1	C = 1	each	C23-K-44410	Gas mask repair	See paragraph C2.01.
Masks, protective, field, M9A1 or	1,050 plus C = 60	each	C23-M-109-10 C23-M-109-20 C23-M-109-30 C23-M-109-40 C23-M-109-50 C23-M-109-60	Personnel protection	See TM 3-205, <u>The Gas Mask</u>.
Masks, gas, lightweight service, M3A1-10A1-6	1,050 plus C = 60	each	C23-M-1510		
Canister, spare, M11 for M9A1 or			C23-C-101	Personnel protection	
Canister, spare, M10A1, for LWS mask	1,000 plus C = 60	each	C23-C-1610	Personnel protection	

Table 7

ITEMS RECOMMENDED FOR BIOLOGICAL WARFARE DEFENSE (Continued)

Item	* Suggested Requirements	Unit	Stock Number	Use	Remarks
Portable air lock	C = 0.9	each	See remarks	For use with existing facilities to improvise protective shelters. Manufactured locally	Y&D Drawing Numbers 566814, 815, 816, 575412 and 413.
Heater, water, portable, M1 (issued for cold climates only)	C = 0.14	each	C66-H-362	Provide hot water for decontamination operations	See BUDOCKS TP-PL-3 or Army TM 3-228, Heater, Water, Portable, M1.
Collective protector, Army M6, 300 CFM electric- or gasoline-operated	C = 4.4	each	C66-F-387-215 C66-F-387-235	For pressurizing shelters	See BUDOCKS TP-PL-3, Chemical Warfare Defense or Army TM 3-350, Gasproof Shelters.
Collective protector 5,000 cfm (E31) GMD or (E35) EMD	C = 0.27	each	See remarks	Air purification in personnel shelters	Development of this item is nearly complete by Army. Issue to be by District level. See paragraph C3.02.
Collective protector 600 cfm (E28) GMD or (E32) EMD	C = 2.2	each	See remarks	Air purification in personnel shelters	Development of this item is nearly complete by Army. See paragraph C3.02.
Filter, particulate, M3, for M6 collective protector	C = 8.8	each	C66-F-442-87		
Sulphanator vacuum solution feed	C = 0.15	each	See remarks	Used in dechlorination process, during decontamination of water	Standard chlorinator may be substituted for this item.
Sampling kits	C = 0.8	each		Sampling for contamination	
Sampling kit refills	C = 2.4	each		Sampling for contamination	
Decontaminating apparatus, Army M1, 3-gal	C = 7.5	each	C41-S-4079-10		See BUDOCKS TP-PL-3 or Army TM 3-220, Decontamination.
Decontaminating apparatus, power-driven, M3A2, M4 or M6	C = 0.28	each	C78-A-1300 C40-S-61050	Decontamination of exterior surfaces	See BUDOCKS TP-PL-3 or TM 3-222 and TM 3-223, Decontaminating Apparatus M3A2 or M4.

*Items that are strictly a function of personnel are recommended on the basis of quantity per 1,000 men. Other items are given as a function of station factor.

APPENDIX A

Chemical Safety Data Sheet SD-38

PROPERTIES AND ESSENTIAL INFORMATION

FOR

SAFE HANDLING AND USE

OF

ETHYLENE OXIDE

•

ADOPTED 1952

Chemicals in any form can be safely stored, handled or used if the physical, chemical and hazardous properties are fully understood and the necessary precautions, including the use of proper safeguards and personal protective equipment, are observed.

Manufacturing Chemists' Association, Inc.

246 Woodward Bldg., 15th & H Sts., N. W., Washington 5, D. C.

CHEMICAL SAFETY DATA SHEET

ETHYLENE OXIDE

SUMMARY

Ethylene oxide is a chemical widely used both in the chemical industry and research laboratories. Its use involves a variety of hazards. These are clearly set forth in this Chemical Safety Data Sheet. Requisite precautions are outlined with regard to its flammable vapors and explosion hazards arising from its variable physical state, as well as when the chemical is subjected to polymerization conditions, particularly when in contact with certain catalytic influences. Likewise the common hazards involved in handling; loading and unloading of tank cars and drums; storage conditions, and buildings, including waste disposal, are placed in proper safety perspective with respect to pertinent safeguards.

Utmost care and diligence have been exercised in pointing out the hazards that might occur if adequate protection and safety precautions are not followed. In view of the extreme care necessary to protect handlers, considerable space has been devoted to the proper choice of protective equipment, suitable clothing, eye protection, masks, etc.

It is important that the suggestions given for first aid in case of exposure be followed. No cases of chronic poisoning by ethylene oxide have been reported, but exposure to excessive concentrations may result in distressing acute effects, including skin burns, injury to the eyes, and irritation of the mucous membranes of the nose and throat. Nausea and vomiting also may occur.

To avoid all dangers and hazards, particular stress is placed on thorough education of employees. In order to appreciate fully the respective danger signals it is urgent that each part and specific section of the Safety Data Sheet on ethylene oxide be carefully examined.

TABLE OF CONTENTS

Manual
Sheet
SD-38

Chemical Safety Data Sheet

ETHYLENE OXIDE

Adopted February, 1951

1. NAME

Chemical Names:	Ethylene oxide, 1,2-epoxyethane; oxirane; dimethylene oxide
Common Names:	Ethylene oxide
Formula:	CH_2-CH_2 0

2. PROPERTIES

2.1 Grades and Strength

Commercial, substantially 100%.

2.2 Important Physical and Chemical Properties.

	Liquid	*Gas*
Boiling Point (760 mm):	10.73° C (51.3° F)	—
Coefficient of Expansion,		
20° C (68° F):	0.00161 per °C	—
55° C (130° F):	0.00170 per °C	—
73.9° C (165° F):	0.00205 per °C	—
Color:	Colorless	Colorless
Corrosivity:	Noncorrosive	Noncorrosive
Critical Pressure; lb./sq. in. abs.:	—	1043
Critical Temperature:	—	195.8° C (384.4° F)
Explosive Limits: See 2.3.3; 6.2.2 and 8.3.2(d)	Non-explosive	Explosive
Per cent by volume in air;		
Upper Limit:	—	100 } See 8.3.2(d)
Lower Limit:	—	3 } See 8.3.2(d)
Flash Point; Liquid Ignition Temp. (decomposition)		
Tag Glass Open Cup:	<0.° F	—
Heat of Combustion; Kgm.cal./gm mol:	—	308.7
Heat of Decomposition; Kgm.cal./gm mol:	—	20.0
Heat of Vaporization; 1 atm., BTU/lb.:	245	—
Hygroscopicity	Slight	—
Ignition Temperature; In air, 1 atm.:	—	429° C (804.2° F)
Ignition Temperature, (Auto-ignition); 1 atm.:	—	571° C (1060.8° F)
Melting Point:	—111.3°C (—168.3°F)	—

Odor:	Characteristic ether-like odor, but irritating in high concentration.	Characteristic ether-like odor, but irritating in high concentration.
Reactivity, Chemical:	Dangerously reactive; some reactions uncontrolled.	Dangerously reactive; some reactions uncontrolled.
Specific Gravity, apparent; 20/20° (68° F):	0.8711	—
Specific Heat:	0.44 BTU/lb. per degree F	0.268 Cal/gram per °C (1 atm. 34° C)
Solubility in Water:	Complete	—
Vapor Density; Air—1 at 40° C (104° F):	—	1.49
Vapor Pressure; 20° C, lb./sq. in. abs.:	—	21.2 (see following table)
Volatility	Very volatile	

Vapor Pressure

Temperature		Vapor Pressure of Ethylene Oxide		
°C	°F	mm Mercury abs.	Inches mercury abs.	Psig abs.
—57.0	—70.6	19.5	0.76	—
—30.4	—22.7	110.6	4.35	—
—10.5	—14.9	312.7	12.31	—
0.0	32.0	493.1	19.41	—
10.73	51.3	760.0	29.92	14.7
20.0	68.0	1095.0	43.11	21.2
30.0	86.0	1560.0	61.42	30.0
69.8	157.6	5141.0	202.4	96.5
109.8	229.6	12,720.0	500.8	245.0

2.3 Hazardous Properties

2.3.1 *HEALTH HAZARDS*

Ethylene oxide vaporizes rapidly at atmospheric temperatures and pressures. Its vapor is moderately toxic by inhalation, and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

2.3.2 *FIRE HAZARDS*

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential fire hazard when it is stored, handled or used. Ethylene oxide fires will continue to burn until the liquid is diluted with approximately 22 volumes of water to one volume of oxide. Most small fires may be extinguished with carbon dioxide or dry chemical agents, if properly applied. (See 6.2.1 Fire Hazards.)

2.3.3. *EXPLOSION HAZARDS*

Liquid ethylene oxide itself is quite stable to detonating agents, but the vapor will explode when exposed to an electric spark, static electricity, excess heat, an open flame, decomposing acetylides, or detonating agents. Vapor and air mixtures are more explosive than the vapor alone and must be handled accordingly. In a confined space the explosion pressure developed may be in the range of 16 to 50 (plus) times the initial pressure depending on the initial pressure and the volume-to-surface ratio of the container. As the volume-to-surface ratio of the container is increased pressures might be developed in excess of 50 times the initial pressure. Explosions from internal sources may be prevented by proper dilution with an inert gas such as nitrogen. Ignition from outside sources should be guarded against by adequate insulation and water spray systems. (See 6.2.2 Explosion Hazards.)

2.3.4 *POLYMERIZATION HAZARDS*

Ethylene oxide may rearrange chemically and/or polymerize violently when in contact with highly active catalytic surfaces such as anhydrous iron, tin, and aluminum chlorides; pure iron and aluminum oxides; and alkali metal hydroxides. (See 6.2.3 Polymerization Hazards.)

Ethylene oxide may also react with other materials and thus create enough heat to accelerate polymerization of unreacted oxide (See 5.2.3).

3. USUAL SHIPPING CONTAINERS

3.1 Type and Size

Cylinders, steel; one pound capacity; ICC-3B300

Cylinders, steel; one-gallon capacity; ICC-4B400

Lagged steel drums; not over 61 gallon capacity; ICC-5P (maximum filling capacity for 61 gallon drum must not exceed 55 gallons of ethylene oxide at 60° F).

Tank Car, insulated; ICC 104A; 104A-W, or ARA-IVA.

3.2 Label or Identification

3.2.1 The Manufacturing Chemists' Association recommends the following label in addition to, or in combination with, any label warning required by statutes, regulations, or ordinances:

3.2.2 ICC Regulations require the ICC red label for flammable liquids.

3.2.3 Tank cars and railroad cars carrying one or more containers of ethylene oxide must bear the ICC "DANGEROUS" placard.

3.3 Disposal and Return Precautions

3.3.1 Small containers (ICC-3B300 and ICC-4B400) should be drained free of liquid ethylene oxide and the valves closed tightly before they are returned to the supplier. No air should be permitted to enter the container.

3.3.2 Insulated Drums and Tank Cars: When all of the liquid ethylene oxide has been removed from the insulated drum or car, the valves should be closed and the valve plugs replaced. No air should be permitted to enter the vessel. The inert gas used for the unloading procedures (See 4. UNLOADING AND EMPTYING) should be left in the drum or tank car at a pressure not in excess of 35 psig at 70° F. A pressure of 35 psig is felt advisable because the resulting partial pressure of ethylene oxide will be low enough to be outside the detonable range. A residual pressure of 35 psig is definitely indicated as a safety measure.*

3.3.3 Ethylene oxide containers should not be used for any other product.

3.3.4 As soon as a tank car is completely unloaded, all valves must be made tight, the unloading connections must be removed and all

ETHYLENE OXIDE

DANGER! EXTREMELY FLAMMABLE
VAPOR HARMFUL
MAY CAUSE BURNS

KEEP AWAY FROM HEAT, SPARKS AND FLAMES.

KEEP CONTAINER CLOSED.

AVOID BREATHING VAPOR.

AVOID CONTACT WITH SKIN, EYES AND CLOTHING.

In case of contact, immediately remove all contaminated clothing, including shoes, and flush skin or eyes with plenty of water for at least 15 minutes: for eyes, get medical attention.

*Recognition of this recommendation is evidenced by amendments to ICC Regulations now being processed; however, pending enactment, currently applicable ICC requirements must be complied with.

other closures made tight, except that heater coil inlet and outlet pipes (if any) must be left open for drainage. Heater coils must never be used in unloading ethylene oxide. Empty tank cars, drums, and other containers should be returned as promptly as possible, in accordance with instructions received from the shipper. Shipper's routing instructions should always be followed strictly. (See 4.3.4)

3.3.5 Follow ICC Regulations regarding the replacement of closures; condition and labeling of empty containers; condition of empty cars, and placard requirements before returning to the shipper. The ICC "DANGEROUS" placards on sides and ends of tank cars must be removed, or reversed (if in metal placard holders), by the party discharging the tank car. The empty tank car must be offered to the receiving carrier either without placards, or preferably with four (4) "DANGEROUS — EMPTY" placards. Placards must be removed from empty railroad cars of other types.

4. UNLOADING AND EMPTYING

4.1 Health Hazards

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

4.2 Fire Hazard

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential fire hazard where it is stored, handled, or used. (See 2.3.2 and 6.2.1 Fire Hazards.)

4.2.1 *EXPLOSION HAZARDS*

Ethylene oxide vapor may explode when exposed to static electricity, electric sparks, excess heat or detonating agents. Dilution of the vapor phase with an inert gas is a recommended safety precaution. (See 2.3.3 and 6.2.2 Explosion Hazards.)

4.3 Tank Cars

Detailed instructions for unloading tank cars containing flammable liquids are set forth in MCA Manual Sheet TC-4. (Also see ICC regulations, Sec. 74.560 to 74.563 inclusive, for unloading tank cars.) A few instructions which are specific for tank cars in ethylene oxide service are given below.

4.3.1 Shipper's instructions should always be followed and all caution markings on both sides of tank and dome should be read and observed.

4.3.2 In the event of a tank car or fitting failure or leak, the shipper should be telephoned or wired immediately for instructions. (See 6.3 Spills and Leakage.)

4.3.3 Tank cars should be electrically grounded to dissipate static or induced lightning charges.

4.3.4 No heat should be applied to the tank car. An inert gas line should be attached to vent connection of the tank car to provide a pressure of 35 psig and not over 65 psig for transfer of the oxide from tank car to receiving tank. Cylinder nitrogen is often used as the pressuring medium in the event a suitable inert gas is not available within the plant. When converted ICC-104 or ARA-IV cars are used under authority of ICC Regulations, Sec. 73.124(5), transfer pressure must not exceed 50 psig. If a pump is utilized, a pressure of 35 psig must be maintained to keep the vapor phase of the tank car in a non-explosive range. (See Figure I for details of unloading arrangement.)

4.3.5 Tank cars in ethylene oxide service are equipped with excess flow check valves. A too rapid opening of the discharge valves will cause the check valves to close. If this should occur, the outlet valve should be closed until the pressure is equalized and the excess flow valve opens.

4.3.6 No air should be allowed to enter the car. The inert gas at 35 psig pressure should be left in the car for the return of the empty tank car. (See 3.3 Disposal and Return Precautions.)

4.4 Insulated Drums (See 4.3.4)

Detailed instructions are supplied by the shipper. (See 4.3.4 Figure I.)

4.4.1 Drums should be unloaded carefully to prevent damage. Drums containing ethylene oxide should be set upright during storage and for unloading.

4.4.2 If any leaking drums are found, they should be removed to a safe location where the

leaking can be stopped or the contents transferred. It should always be remembered that ethylene oxide vapors are flammable and toxic. (See 6. HANDLING.)

4.4.3 If it is not practical to locate the insulated drum outdoors during unloading, a vent stack or hood equipped with an exhauster should be installed over the drum.

4.4.4 An inert gas is used to empty a drum of its contents. Heating increases the explosion hazard (See 2.3.3 and 6.2.2 Explosion Hazards). In addition, heating may cause polymer formation.

4.4.5 If ethylene oxide vapor is required by the user, it will be necessary to provide a vaporizer. The size and arrangement of such will be dependent upon the requirements of the user. The vaporizer, however, should be designed to contain a minimum volume of ethylene oxide and to have a maximum surface. (See 6.2.2 Explosion Hazards.) If possible, the vaporizer should be located outside of buildings to prevent the accumulation of ethylene oxide vapors in case of any leakage.

4.4.6 When unloading liquid ethylene oxide from an insulated drum, a total gas pressure of 35-40 psig at 70° F. should be maintained in the drum through the vent connection, and the flow of liquid regulated by the discharge valve. All piping and equipment should be made of steel and properly grounded. (See 6. HANDLING.)

4.4.7 Check valves should be installed in the discharge line to prevent reactants from entering a drum. (See 6. HANDLING.)

4.4.8 If more than 50 psig pressure is desired by the user in a manufacturing process, it will be necessary to install a pump because the safe working pressure of the insulated drum is only 50 psig.

4.4.9 When the drum has been emptied of its contents, an inert gas pressure of 35 psig at 70°F. should be left in the drum for return to the shipper. No air should be allowed to enter the drum. (See 3.3.2)

4.4.10 If the drum is emptied only partially of its contents at any one usage, total gas pressure of 35 psig at 70° F. should be left in the drum for storage. (See 5. STORAGE.)

4.5 Small Cylinders

4.5.1 Precautions generally applied to use of small cylinders (ICC-3B300 and ICC-4B400) of flammable liquids should be used.

4.5.2 A water bath heated to a maximum of 50° C. (122° F.) may be used to empty a small uninsulated container by means of the vapor pressure of the ethylene oxide.

4.5.3 Check valves must be installed in feed lines from the cylinder to prevent the reactants from entering the cylinder.

4.5.4 When the cylinder is empty, the valve should be closed. Air should not be allowed to enter the container.

5. STORAGE

5.1 Hazards

5.1.1 *HEALTH HAZARDS*

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

5.1.2 *FIRE HAZARDS*

Ethylene oxide is an extremely flammable liquid and, as such, introduces a potential hazard where it is stored, handled, or used. (See 2.3.2 and 6.2.1 Fire Hazards.)

5.1.3 *EXPLOSION HAZARDS*

If not diluted with an inert gas, ethylene oxide vapor may explode when ignited within a confined space. (See 2.3.3 and 6.2.2 Explosion Hazards.)

5.1.4 *CORROSION*

Ethylene oxide is noncorrosive.

5.1.5 *VOLATILITY*

Ethylene oxide is very volatile and should be stored under pressure with adequate cooling. (See 2.2 Important Physical and Chemical Properties and 5.2 Conditions of Storage.)

5.1.6 *TEMPERATURE REQUIREMENTS*

Ethylene oxide in storage tanks should be maintained at a temperature not exceeding 30° C. (86° F.). Ethylene oxide in insulated drums or small containers should be stored in a cool, well-ventilated area. (See 5.2 Conditions of Storage and 6.2.2 Explosion Hazards.)

5.2 Conditions of Storage

5.2.1 *MATERIAL AND TYPE OF CONSTRUCTION.*

All piping (including instrument leads), storage tanks, relief devices and equipment employed to handle ethylene oxide should be of steel or stainless steel and designed to have a working pressure of at least 50 psig with a safety factor conforming to the A.S.M.E. Code. Shut-off valves and control valves should be of steel or stainless steel designed for working pressures of 150 psig or over. Copper or other acetylide-forming metals, such as silver, magnesium and their alloys should not be used as materials of construction for equipment handling ethylene oxide. Mercury-filled instruments should be provided with mercury traps and an inert gas purge which is free of acetylene and carbon dioxide. All-welded construction is preferred to riveted construction. Storage tanks should be equipped with cooling coils and should be well insulated. All liquid inlet lines should enter or lie extended to the bottom of the vessel to prevent the generation of static electricity. All equipment should be properly grounded and an efficient water spray system should be installed. Adequate diking and drainage should be provided in the tank area to confine and dispose of the liquid in case of tank rupture.

5.2.2 *ISOLATION*

Local building codes should be followed strictly. Ethylene oxide storage tanks should be isolated from continuous ignition sources such as boiler houses. If possible, storage tanks should be located outside of buildings. Insulated drums containing ethylene oxide should be stored always in a vertical position, outside of buildings, and in an isolated and well-ventilated area. It is preferable to store the containers in the open, but provision should be made to shield them from the direct rays of the sun and to prevent accumulation of dirt, snow, water, or ice on valves or safety devices. The use of an open-sided storage shed is suggested.

5.2.3 *COMPATIBILITY WITH OTHER MATERIALS*

Storage tanks in ethylene oxide service should be used only for ethylene oxide unless thoroughly cleaned and purged. (See 6.8 Tank and Equipment Cleaning and Repair.) Ethylene oxide reacts exothermically with such compounds as alcohols, amines, ammonia, and organic and mineral acids. Before a tank is placed in ethylene oxide service, it should be cleaned thoroughly, flushed with water and dried. Before ethylene oxide is placed in the tank, the vessel should be purged with an inert gas until free of air.

5.2.4 *VAPOR-PROOF OR EXPLOSION-PROOF REQUIREMENTS*

All electrical equipment, motors, lights, and flashlights used in an area in which oxide is stored or handled should conform to the National Electrical Code and should be vapor-tight.

5.2.5 *EXPLOSION VENTING REQUIREMENTS*

An adequate system for normal and emergency venting should be installed. All vent lines should extend to a safe area. The point of outlet should be equipped with an approved flame arrestor. Relief valves should be installed in pairs to facilitate periodic testing and repairing. The vent line should be equipped with a connection for emergency purging with steam, nitrogen or carbon dioxide for the extinguishment of any fire occurring on the outlet side of the flash arrestor.

5.2.6 *VENTILATION*

All storage areas should be provided with continuous ventilation. Pits, depressions and basements should be avoided.

5.2.7 *PROTECTION FROM ELECTRICAL STORMS*

Storage tanks for ethylene oxide should be protected from electrical storms and induced static electricity by grounding of all equipment.

5.2.8 *PROTECTION FROM INTERNAL IGNITION*

Storage tanks and other equipment should be maintained under an inert atmosphere in a non-flammable range during all transfers, as well as during stationary conditions, to prevent possible ignition in the vapor phase within the vessel. Vessels should be provided with bottom inlets under the liquid, or tangented nozzles to prevent static sparks. (See 5.2.1) (See 6.2.2 Explosion Hazards.)

6. HANDLING

6.1 Health Hazards

Ethylene oxide vaporizes rapidly at ordinary temperatures, and its vapor is moderately toxic by inhalation and is irritating to the eyes and mucous membranes. Ethylene oxide as pure liquid, or in solution, can produce burns of the skin and eyes. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.2 Fire, Explosion, and Polymerization Hazards

6.2.1 *FIRE HAZARDS*

Ethylene oxide should be handled with all precautions generally observed in handling flammable liquids. Fires involving large quantities of liquid are difficult to extinguish, although ethylene oxide is soluble in water. The fire will continue to burn until the liquid is diluted with approximately 22 volumes of water to one of oxide. Most small fires can be extinguished with carbon dioxide or dry chemical agents if properly applied. Adequate fire extinguishing equipment, fixed and portable, should be provided. Diking and drainage should be provided for confining and disposing of the liquid in case of tank rupture.

6.2.2 *EXPLOSION HAZARDS*

Liquid ethylene oxide is quite stable to explosion initiators but, as a vapor, ethylene oxide may undergo rapid decomposition if an explosion is initiated. This action is accompanied by the liberation of a considerable amount of energy (See 2.2 Important Physical and Chemical Properties) and, if in a confined space, will produce an increase in pressure of 16 to 50 (plus) times the initial pressure. The pressure ratio varies with the ratio of volume to surface of the containing vessel. Detonating acetylides, static electricity, excess heat, "hot spots," open flames, or other detonators may explode ethylene oxide vapors. If a vessel containing ethylene oxide is not insulated or protected by a film of water and becomes enveloped by fire, the vapor may be heated quickly above the auto-ignition temperature of 571° C. (1060° F.). (See 2.2 Important Physical and Chemical Properties.) Ignition within a vessel containing ethylene oxide may be prevented by proper dilution of the vapor phase with an inert gas. Any inert gas selected should be free of such impurities as air, acetylene, sulfur, hydrogen sulfide, water, ammonia, or carbon dioxide. (Dilution data, composition versus temperature and pressure, are available for common inert gases.) Ignition from fire exposure should be guarded against by adequate insulation and automatic water spray systems. Storage tanks and processing equipment handling ethylene oxide should be free from air because air reduces the percentage of oxide vapor required for an explosive mixture.

6.2.3 *POLYMERIZATION HAZARDS*

Ethylene oxide may rearrange and/or polymerize violently, liberating large quantities of heat. A few of the most notable catalysts for this type of reaction are: anhydrous iron, tin, and aluminum chlorides; pure iron and aluminum oxides; metallic potassium; alkali metal hydroxides; acids and organic bases. The speed of the reaction varies with the purity of the reactants, the temperature, the relative amount of each reactant, and the method of application.

6.3 Spills and Leakage

6.3.1 Frequent inspections of equipment and vessels containing ethylene oxide should be made to detect or prevent leaks.

6.3.2 If leaks or spills occur, only properly protected personnel should remain in the area (See 8.3 Personal Protective Equipment).

6.3.3 All spills should be flushed away promptly with a large quantity of water (See 6.2.1 Fire Hazards). All openings in sewer system should be trapped for segregation and extinguishment. All sources of ignition should be removed.

6.3.4 If possible, increased ventilation should be provided. Inhalation of vapors should be avoided. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.3.5 All articles of clothing, including shoes, wet with ethylene oxide or exposed to oxide vapors should be removed immediately and the body washed to remove any of the ethylene oxide which has penetrated the clothing. Clothing should be washed before re-use.

6.3.6 A leaking container should be removed to an isolated, well-ventilated area and the contents transferred to other suitable containers. Unloading rules set forth in Section 4 should be observed.

6.3.7 In the event of a tank car leakage, dilute leakage with large quantity of water, and make necessary repairs, if possible. The supplier should be telephoned or wired immediately for specific instructions.

6.4 Employee Education and Training

6.4.1 Workers who handle ethylene oxide, or may be exposed to it in any form, should be instructed carefully in accepted methods of handling and be familiar with the protective equipment required for safe handling. Instruction should stress the hazard for any fire or explosion and contact of the material with the skin and eyes, and avoiding inhalation of the vapors.

6.4.2 All workers should be familiar with the location of safety showers, alarm boxes, emergency ventilation system and hose lines.

6.4.3 Each employee should be reinstructed periodically in the hazards involved and proper emergency measures to take.

6.5 Personal Protective Equipment

6.5.1 *AVAILABILITY AND USE*

Personal protective equipment is not an adequate substitute for good, safe, working conditions, adequate ventilation and intelligent conduct on the part of employees working with ethylene oxide. Such equipment may protect the individual wearing it while others in the area may be exposed to danger. The correct usage of personal protective equipment requires the education of the worker in the proper employment of the equipment available to him. (See 6.4 Employee Education and Training.) Under conditions which are sufficiently hazardous to require protective equipment, the use of it should be supervised.

The following personal protective equipment should always be used for the purposes mentioned, and as specified in 8. HEALTH HAZARDS AND THEIR CONTROL and in other sections of this publication.

6.5.2 *EYE PROTECTION*

6.5.2.1 *Chemical Safety Goggles*: Cup-type or rubber-framed, vapor proof goggles, equipped with approved impact resistant glass or plastic lenses, should be worn whenever there is danger of the material (in liquid or vapor form) coming in contact with the eyes. Goggles should be carefully fitted by adjusting the nose piece and head band to insure maximum protection and comfort.

6.5.3 *RESPIRATORY PROTECTION*

Respiratory protective equipment must be carefully maintained, inspected, cleaned and sterilized at regular intervals, and always before use by another person. Personnel wearing such equipment must be carefully instructed as to its operation and limitations.

6.3.5.1 Air-supplied masks, equipped with full face pieces, must be worn for protection under the following conditions:

(a) In emergencies, when the vapor concentration is not definitely known.

(b) When the harmful vapor concentration is over 2 per cent by volume.

(c) When the oxygen content of the air may be less than 16 per cent by volume.

(d) When the exposure period is to be over 30 minutes' duration.

(e) In tank and equipment cleaning and repair work, when (a), (b), (c) and (d) apply.

6.5.3.2 Only masks approved by the Bureau of Mines should be used, and the manufacturers' instructions must be carefully followed. Types generally available include:

(a) Air-line masks supplied by plant compressed air are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. Such masks should be used only in conjunction with a suitable reducing or demand-type valve and filter, and with excess pressure relief valve. The compressed air should be checked frequently to make certain that harmful gases such as from the decomposition of the lubricating oil used in the compressor or impure air supply are not present.

(b) Positive-pressure hose masks supplied by externally lubricated blowers are usually preferred to the air-line type. Since these masks also depend on a remote air supply, they should be used only where conditions will permit safe escape in the event of air supply failure. Care must be taken to locate the source of the blower air in an area which is free of air contaminants.

(c) Self - contained breathing apparatus which permits the wearer to carry a supply of air in the cylinder allows for greater mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air supply carried. In tank work, where small manholes are encountered, a self-contained breathing apparatus is usually unsuitable because of its bulk.

6.5.3.3 Industrial canister-type gas masks, approved by the Bureau of Mines, fitted with the proper canister for absorbing ethylene oxide vapor, (or gas), and equipped with full face pieces, will afford protection against concentrations not exceeding 2 per cent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air must be not less than 16 per cent by volume. The masks should be used for relatively short

exposure periods only, i.e., less than 30 minutes. They may not be suitable for use in an emergency since, at that time, the actual vapor concentration is unknown and it may be very high. The wearer must be warned to leave the contaminated area immediately on detecting the odor of a harmful vapor. This is an indication that the mask is not functioning properly or that the vapor concentration is too high.

NOTE: When carbon monoxide may be encountered in addition to ethylene oxide, the mask should be equipped with an all-purpose canister and a timing device as approved by the U.S. Bureau of Mines.

6.5.4 *HEAD PROTECTION*

6.5.4.1 Safety or "hard" hats will provide protection against accidental liquid leaks, falling tools and other objects.

6.5.4.2 Brimmed felt hats may be substituted for a safety hat where the danger of falling objects is remote.

6.5.5 *FOOT PROTECTION*

Leather or rubber safety shoes with built-in steel toe caps are recommended. Rubbers may be worn over leather safety shoes.

NOTE: Ethylene oxide may penetrate leather and rubber, but up-to-date rubber is probably the best available protective material.

6.5.6 *BODY, SKIN AND HAND PROTECTION*

6.5.6.1 Suits made of a suitable protective material, and properly designed should be used to provide complete body protection, when necessary.

6.5.6.2 Aprons made of suitable protective material should be used for protection against accidental contact.

6.5.6.3 Gloves made of suitable protective material should be worn to protect the hands from ethylene oxide.

6.5.6.4 Sleeves made of suitable protective material should be worn when the need for complete arm protection is indicated.

6.5.6.5 Life harness and life line should be worn by men working in tanks or other confined spaces to facilitate rescue.

6.5.6.6 Whenever necessary, facilities for personal cleanliness should be provided and time allowed for thorough washing before lunch and at the end of the work day.

6.6 **Engineering Controls**

6.6.1 Because ethylene oxide is an extremely flammable liquid and the vapor is explosive and toxic under certain conditions, processes should not be located near open flames, high temperatures or congested areas. (See 5.2 Conditions of Storage.)

6.6.2 Processes should be designed so that the operator is not exposed to direct contact with ethylene oxide or its vapor. The technical problems of designing equipment, providing adequate ventilation, and formulating operational procedures which promise maximum security and economy, can be handled best by engineers or other competent personnel. The manufacturers of ethylene oxide, and of the equipment in which it is to be used, are always prepared to help with these problems.

6.6.3 For each installation, a written set of operating instructions should be prepared and posted adjacent to the operation. The procedure should be checked frequently by the supervisor in order to maintain proper controls.

6.6.4 In the handling of ethylene oxide or operation of any type of ethylene oxide system, all valves, pipe lines, vents, safety devices, etc., should be so located that they can be readily inspected and cleaned periodically to prevent plugging and should always be in proper order and condition before the operation is started. All handling and storage equipment should be located away from all possible source of sparks, flames and heated surfaces. All charging and discharging pipes should enter through, or extend to, the bottom of all containers to minimize vaporization of the liquid and possible generation of static electricity. (See also 5.2.7 and 5.2.8.)

6.6.5 It is essential for safety that equipment be used and maintained as recommended by the manufacturer and that a periodic test schedule of the equipment, including safety devices, should be followed.

6.6.6 The manufacturer's recommendation as regards the unloading and loading of shipping containers should be followed with caution to avoid static from streams in tanks.

6.6.7 Due to the tendency of ethylene oxide to leak through even the smallest opening, welded rather than threaded connections are recommended on all equipment containing this chemical.

6.7 Ventilation

6.7.1 If the workroom or operating area is separate from ethylene oxide storage or processing equipment, general ventilation is adequate. For emergencies, however, the area should be provided with mechanical exhaust ventilation.

6.7.2 In the processing or storage area, if outside location is impracticable, special emergency equipment for ventilation is necessary under abnormal conditions, such as leaks or spills.

6.7.3 Twelve changes of air per hour are considered adequate for buildings housing storage or processing equipment for flammable liquids, vapors, or gases under pressure.

6.7.4 Buildings of substantial construction should have at least 1 sq. ft. of door, window, or non-rigid roof area for each 35 cu. ft. of volume to prevent serious structural damage in the event of explosion within the building.

6.7.5. A remote manual control should be provided for forced ventilation systems, to be used in the event of an emergency.

6.8 Tank and Equipment Cleaning and Repairs

6.8.1 Cleaning or making repairs inside of equipment in which ethylene oxide is contained is particularly hazardous because of its toxicity and flammability. (See 8. HEALTH HAZARDS AND THEIR CONTROL.)

6.8.2 Safety respiratory apparatus, protective clothing, spark-proof tools, and explosion-proof lights should be provided for repair or cleaning crews.

6.8.3 Written approval of supervisor should be procured by the repair or cleaning crews.

6.8.4 The liquid ethylene oxide should be pumped out or transferred. Any pressure on the equipment should be vented to a safe area or through a scrubber. The equipment should be filled with water, drained, and thoroughly washed before it is entered for any inspection or repairs.

6.8.5 All connections to vessels should be blanked off and the air in the tank tested with a combustible gas indicator approved for ethylene oxide. Gas tests should be repeated from time to time if continued work within the equipment is necessary.

6.8.6 A "watcher" supplied with the specified safety equipment should be stationed outside the equipment entrance to keep the men inside under constant observation. Additional men should be available for rescue work. (See 8.3.2)

6.8.7 Special ventilation is recommended during the entire time men are cleaning, repairing, or inspecting the equipment.

6.8.8 Before the equipment is returned to ethylene oxide service, an inert gas should be used to purge out all of the air. If the gas used for purging forms a flammable gas-air mixture, the equipment should be filled with water and then blown with the gas, vented to a safe location, until dry.

6.9 Repackaging

This entire manual should be carefully reviewed by the repacker so that he may become familiar with the hazardous properties of ethylene oxide and the safeguards which should be taken to handle it safely. Only ICC specification containers should be used (See 3.1 Type and Size). The containers should be cleaned thoroughly and dried, and they should be labeled properly (See 3.2 Label or Identification).

6.10 Use in Chemical Reactions

6.10.1 Because of the explosive characteristics of ethylene oxide vapor and the generally exothermic nature of the reaction of the liquid with various materials, precautions are required when feeding it into a reaction mixture.

6.10.2 The vapor phase of reactions under pressure should be diluted or blanketed with an inert gas. (See 6.2.2 Explosion Hazards.)

6.10.3 Proper agitation to assure constant and complete mixing should be provided.

6.10.4 Because the control of temperature and pressure is important, proper instrumentation and some means of cooling the reaction should be provided.

6.10.5 Normal and emergency venting of adequate capacity should be provided.

6.10.6 Check valves should be installed in feed lines in an effort to prevent the reactants from entering a cylinder, vaporizer, or any vessel containing pure ethylene oxide.

6.10.7 All piping and equipment should be made of steel. Do not use copper, silver, magnesium, and their alloys as materials of construction for equipment handling ethylene oxide.

7. WASTE DISPOSAL

7.1 Waste mixtures containing ethylene oxide should not be allowed to enter drains or sewers where there is danger of the vapors becoming ignited. All openings in sewer systems should be trapped for segregation and extinguishment. (See 6.2 Fire, Explosion, and Polymerization Hazards and 6.3 Spills and Leakage.)

7.2 When it becomes necessary to dispose of ethylene oxide as such, it is preferable to do so as a vapor, venting to a safe location. (See 5.2.5 Explosion Venting Requirements.)

7.3 All polymeric wastes are water soluble and, as such, present no major problem. Disposal of these materials, however, depends to a great extent upon local conditions. All Federal, State, and local regulations regarding health and pollution should be followed.

8. HEALTH HAZARDS AND THEIR CONTROL

This section includes a description of the principal health hazards of ethylene oxide, recognized first aid procedures and information of interest to laymen and physicians.

8.1 Hazards

8.1.1 *GENERAL*

The usual contact that occurs in handling ethylene oxide is by inhalation of its vapor. Exposure to low concentrations of vapor often results in delayed nausea and vomiting. Exposure even to low concentration, if continuous, will result in a numbing of the sense of smell; thus harmful concentration may be reached, without warning because of odor. High concentrations of ethylene oxide can produce edema of the lung and irritation of the eyes and mucous membranes.

Liquid ethylene oxide can produce eye burns but when spilled on exposed skin, is generally not immediately irritating, but continued contact may cause burns. When it is spilled on clothing or in the shoes, it is capable of producing a delayed burn of the skin if the wet clothing and shoes are not removed promptly. Rapid evaporation of ethylene oxide on the skin is capable of producing an effect like frostbite.

8.1.2 *ACUTE TOXICITY*

8.1.2.1 *Systemic Effects*

When excessive amounts of ethylene oxide are inhaled, they have a general anesthetic effect as well as causing coughing, due to irritation of the respiratory system. The victim may become nauseated and vomit.

8.1.2.2 *Local Effects*

The vapor will cause eye and nasal irritation when present in excessive amounts. The liquid or solutions on the exposed skin do not cause skin irritation immediately, but when spilled in the shoes or on the clothing, delayed skin burns can occur if the clothing and shoes are not promptly removed. The liquid or solutions may cause severe eye burns. Vapor has been known to produce skin irritation and burns from its absorption by perspiration in areas of heat and moisture about the body. (See 8.4.2.2 Skin Contact and 8.4.2.3 Contact With Eyes.)

8.1.3 *CHRONIC TOXICITY*

No cases of chronic poisoning due to ethylene oxide have been reported.

8.2 Prevention and Control

Ethylene oxide does not present a serious industrial health hazard provided workers are effectively instructed and adequately supervised in the proper handling of the chemical.

8.2.1 *EMPLOYEE EDUCATION*

(See 6.4 Employee Education and Training.)

8.2.2 *VENTILATION*

A maximum allowable concentration of 100 parts per million of ethylene oxide by volume in air has been proposed for an eight-hour working day exposure. Ventilation should be adequate to keep atmospheric concentration below 100 parts per million in places where ethylene oxide is being handled and employees are exposed.

8.2.3 *PRE-EMPLOYMENT PHYSICAL EXAMINATION*

Those who are to work with ethylene oxide should be given a thorough physical examination. In general, asthmatic individuals and those suffering from acute or chronic chest infections should not be exposed to ethylene oxide.

8.2.4 *PERIODIC PHYSICAL EXAMINATIONS*

Workers exposed to ethylene oxide need no special type of specific examination except that attention should be directed to the lungs.

8.3 Personal Protective Equipment

8.3.1 Personal protective equipment is not an adequate substitute for safe working conditions and intelligent conduct on the part of employees who work with ethylene oxide. The employees should be carefully trained and carefully supervised in the correct use of personal protective equipment.

8.3.2 Severe exposures to ethylene oxide may occur in tank and equipment cleaning and repairs, in extensive spillage of the material, or in cases of failure of piping and equipment. Employees who may be subject to such exposures should be provided with proper eye, respiratory, skin, and mucous membrane protection as follows:

(a) Suitable gas-tight chemical safety goggles.

(b) Rescue harness and lifeline for those entering the tank or enclosed storage space. (An assistant provided with indicated protective equipment should be present when such equipment is used.)

(c) Hose mask with hose inlet in vapor-free atmosphere. Air-line masks with proper reducing valve and filter, suitable for use only where conditions will permit safe escape in case of failure of compressed air supply.

(d) Where the period of exposure is not longer than 30 minutes, and when the oxygen content of the atmosphere is above 16 per cent by volume, and concentration of ethylene oxide does not exceed 2 per cent by volume in the air, workers may wear full-faced industrial gas masks approved by the United States Bureau of Mines, with canisters approved for use in the presence of ethylene oxide. Note: 2% is dangerously near the lower explosive limit of 3% for ethylene oxide.

(e) Rubber gloves and apron.

(f) Rubber shoes or boots.

8.3.4 Reliable safety equipment manufacturers can supply appropriate protective equipment if they are informed accurately of the particular product in use. (See 6.5 Personal Protective Equipment.)

8.4 First Aid

8.4.1 First aid should be started at once in cases of contact with excessive amounts of ethylene oxide. Workers presenting symptoms or signs of ethylene oxide poisoning should be removed at once from the contaminated area. A physician should be called at once, notifying him of nature of case and location of the patient.

8.4.2 *SPECIFIC ACTIONS*

8.4.2.1 *Inhalation*

In case breathing has stopped, effective artificial respiration such as that obtained by the prone pressure or by the Eve rocking method* should be started immediately. If oxygen inhalation apparatus is available, oxygen should be administered, but only if one familiar with the operation of such apparatus is present to administer it. A physician should be called at once. In order to prevent the development of severe lung congestion (pulmonary edema), 100 per cent oxygen should be administered as soon as possible after a severe exposure. Oxygen administration is most effective if expiration is made against a positive pressure of 4 cm. (about 1¼ inches) of water. This may be accomplished readily by use of a rubber tube connected to the outlet valve of a snugly fitting face mask and inserted to a depth of not more than 4 cm. below the surface of water in a suitable container. (Special masks are obtainable with adjustable gauges which regulate the positive pressure from 1 to 4 cm.) The pressure resisting exhalation should be adjusted to the patient's tolerance by varying the depth of the end of the tube below the water's surface. Oxygen inhalation must be continued as long as necessary to maintain the normal color of the skin and mucous membranes. In cases of severe exposure, the patient should breathe 100% oxygen under positive exhalation pressure for one-half hour periods every hour for at least three hours. If there are no signs of lung congestion at the end of this period, and if breathing is easy and the color is good, oxygen inhalation may be discontinued. Throughout this time, the patient should be kept comfortably warm, but not hot.

Milder exposures to ethylene oxide vapors at times produce nausea and vomiting. In cases presenting such symptoms, they should be placed in bed and given warm water in sufficient amounts to aid in washing out their stomachs. A physician should be called.

*See F. C. Eve, Journal of American Medical Association (April 1, 1944).

8.4.2.2 *Skin Contact*

All clothing contaminated with liquid ethylene oxide should be removed at once. Clothing, including shoes, should not be worn again until free from ethylene oxide. Shoes can seldom be decontaminated. All affected areas of skin should be thoroughly washed with soap and water.

It has been noted that if shoes are worn which have been soaked in ethylene oxide, delayed skin burns can occur. Even weak solutions which contaminate clothing can produce the same effect, particularly in such areas as the genital region. These burns form blebs or water blisters out of proportion to the amount of skin damage and are usually healed in a week or 10 days if properly treated. (See 8.5)

8.4.2.3 *Contact With Eyes*

Ethylene oxide, as liquid or vapor, is capable of producing eye damage. Should it reach the eyes, the eyes should be irrigated immediately and copiously with water for fifteen minutes. The eyelids should be held apart during the irrigation to insure contact of the water with all the tissues of the surface of the eyes and lids. Should eye irritation persist, the eyes should be irrigated for a second period of 15 minutes and a physician, preferably an eye specialist, should be called in attendance.

8.4.2.4 *Taken Internally*

Due to the nature of ethylene oxide, it is very unlikely that any of it could be taken internally, but if a person has swallowed liquid ethylene oxide or its solutions, he should be made to vomit, if conscious, by having him drink a glassful or more of lukewarm water in which a teaspoonful of salt to the glassful has been dissolved; or a similar amount of warm soapy water may be used. If necessary, the patient should be encouraged to stick his finger down his throat to induce vomiting. When possible, vomiting should be induced at least three times. Following this, a tablespoonful of Epsom salt dissolved in a glass of water should be given. A physician should be called at once.

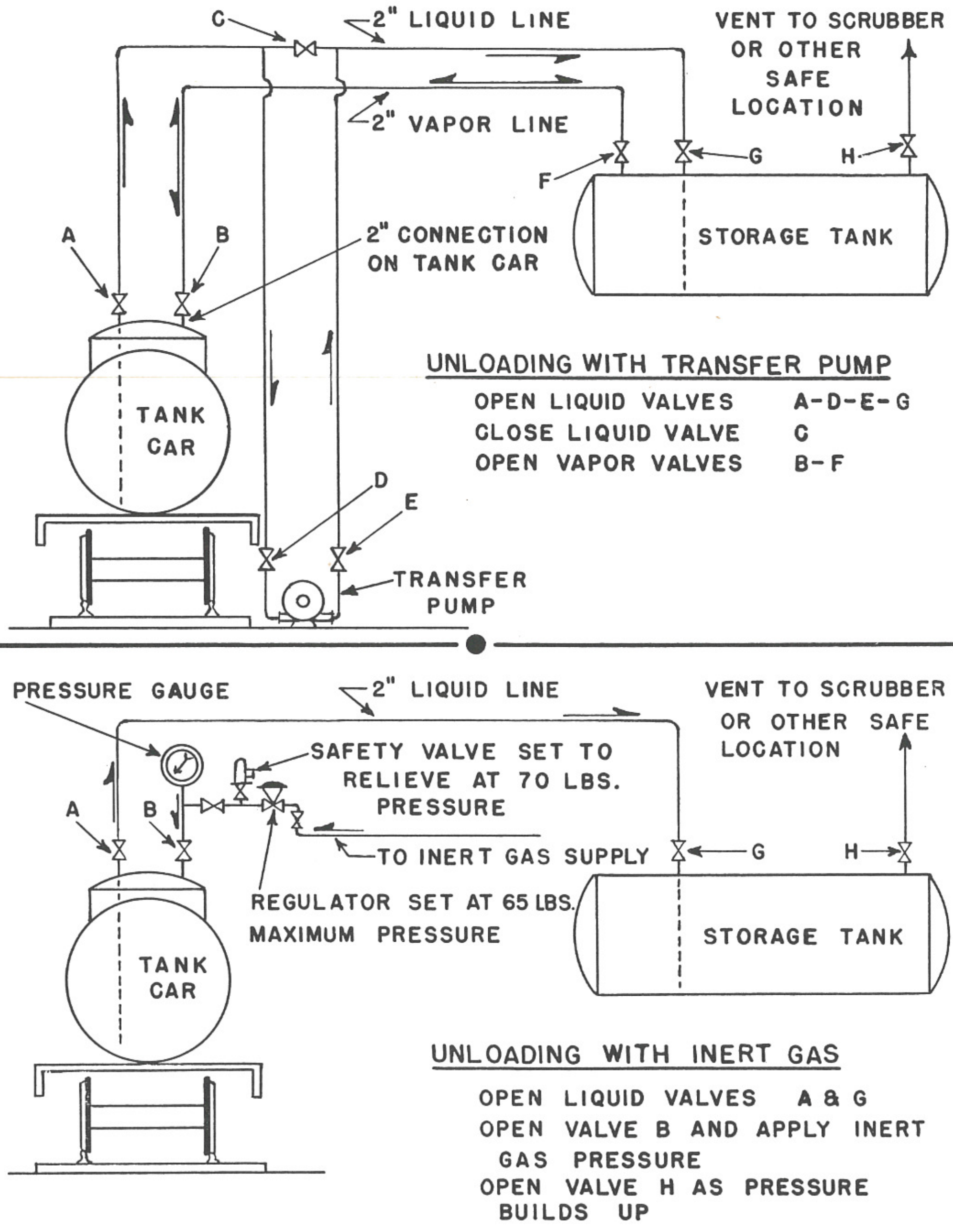
8.5 **Suggestions for Medical Treatment**

Through unpublished reports, it has been found that for persistent nausea and vomiting which may result from inhalation of ethylene oxide, an intramuscular injection of sodium phenobarbital gr. ii is very helpful in controlling such symptoms.

For skin burns resulting in the formation of blebs, if the blebs are evacuated and solid petrolatum dressings are applied, the healing is usually quite prompt. The bleb formation is out of proportion to the actual damage to tissue as the burns are, as a general rule, quite superficial.

The medical information in this publication has been supplied by the Medical Advisory Committee of the Manufacturing Chemists' Association, Inc.

FIGURE I.
UNLOADING LIQUID ETHYLENE OXIDE



NOTE: THE PRESSURES SHOWN APPLY TO ICC-104A, 104A-W & ARA-IVA TANK CARS.

CHEMICAL SAFETY DATA SHEETS

Acetaldehyde	Manual Sheet SD-43	30 cents
Acetic Acid	Manual Sheet SD-41	30 cents
Acetic Anhydride	Manual Sheet SD-15	25 cents
Acetylene	Manual Sheet SD-7	20 cents
Acrylonitrile	Manual Sheet SD-31	25 cents
Ammonium Dichromate	Manual Sheet SD-45	25 cents
Anhydrous Ammonia (Revised)	Manual Sheet SD-8	25 cents
Aniline	Manual Sheet SD-17	25 cents
Aqua Ammonia	Manual Sheet SD-13	25 cents
Benzene	Manual Sheet SD-2	30 cents
Betanaphthylamine	Manual Sheet SD-32	25 cents
Bromine	Manual Sheet SD-49	25 cents
Calcium Carbide	Manual Sheet SD-23	25 cents
Carbon Disulfide	Manual Sheet SD-12	25 cents
Carbon Tetrachloride	Manual Sheet SD-3	25 cents
Caustic Potash	Manual Sheet SD-10	25 cents
Caustic Soda	Manual Sheet SD-9	25 cents
Chlorosulfonic Acid	Manual Sheet SD-33	25 cents
Chromic Acid	Manual Sheet SD-44	25 cents
Cresol	Manual Sheet SD-48	25 cents
Dimethyl Sulfate	Manual Sheet SD-19	25 cents
Ethyl Ether	Manual Sheet SD-29	25 cents
Ethylene Dichloride	Manual Sheet SD-18	25 cents
Ethylene Oxide	Manual Sheet SD-38	30 cents
Formaldehyde (Revised)	Manual Sheet SD-1	25 cents
Hydrochloric Acid	Manual Sheet SD-39	35 cents
Hydrofluoric Acid	Manual Sheet SD-25	25 cents
Hydrogen Sulfide	Manual Sheet SD-36	25 cents
Methanol	Manual Sheet SD-22	25 cents
Methyl Bromide	Manual Sheet SD-35	25 cents
Methyl Chloride	Manual Sheet SD-40	30 cents
Nitric Acid	Manual Sheet SD-5	30 cents
Nitrobenzene	Manual Sheet SD-21	25 cents
Paraformaldehyde	Manual Sheet SD-6	25 cents
Perchloroethylene	Manual Sheet SD-24	25 cents
Perchloric Acid Solution, Preliminary	Manual Sheet SD-11	25 cents
Phenol	Manual Sheet SD-4	25 cents
Phosphoric Anhydride	Manual Sheet SD-28	25 cents
Phosphorus, Elemental	Manual Sheet SD-16	25 cents
Phosphorus Oxychloride	Manual Sheet SD-26	25 cents
Phosphorus Trichloride	Manual Sheet SD-27	25 cents
Sodium Chlorate (Revised)	Manual Sheet SD-42	25 cents
Sodium Cyanide	Manual Sheet SD-30	25 cents
Sodium, Metallic	Manual Sheet SD-47	25 cents
Sodium and Potassium Dichromates	Manual Sheet SD-46	25 cents
Styrene Monomer (Revised)	Manual Sheet SD-37	30 cents
Sulfuric Acid (Revised)	Manual Sheet SD-20	25 cents
Tetrachloroethane	Manual Sheet SD-34	25 cents
Trichloroethylene	Manual Sheet SD-14	25 cents

MANUALS OF STANDARD and RECOMMENDED PRACTICE

Manual L-1	Warning Labels	$1.00

The Chemical Safety Data Sheets, and a complete list of publications including manual sheets on unloading tank cars, drums, and carboys when filled with certain chemical products may be secured from the

MANUFACTURING CHEMISTS' ASSOCIATION, Inc.
246 Woodward Building,
Washington 5, D. C.
U.S.A.

Please send remittance with order.

D58662

PRINTED IN U.S.A.

~~RESTRICTED~~
~~Security Information~~

~~RESTRICTED~~